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Open File Report 5707

Geology of the Monument Bay Area, Lake of the Woods, District of Kenora

1989

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Open File Report 5707

Geology of the Monument Bay Area, Lake of the Woods, District o[illegible]enora

by

M.G. Morrice

1989

This project is part of the Canada-Ontario 1985 Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario.

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V.G. Milne

V.G. Milne, Director
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Foreword

Prior to 1987 the geological database available for the Monument Bay Area of Lake of the Woods, District of Kenora, was at a reconnaissance level. The detailed mapping project described in this report was designed to encourage mineral exploration interest and to provide a basis for land use planning.

The project is part of the Canada-Ontario Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario.

There is no known mineral exploration from the area, but several features make this an attractive region to conduct mineral exploration. Massive sulphide clasts have been observed associated with felsic metavolcanics indicating a promising mineralization environment. A number of samples collected by the author of this report from quartz-carbonate veins in shear zones contain over 100 ppb gold. The highest value obtained is 52.3 ppm gold.

V.G.Milne
Director
Ontario Geological Survey

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Included with this Open File Report is Preliminary Map P.3120 to be found in the back pocket.

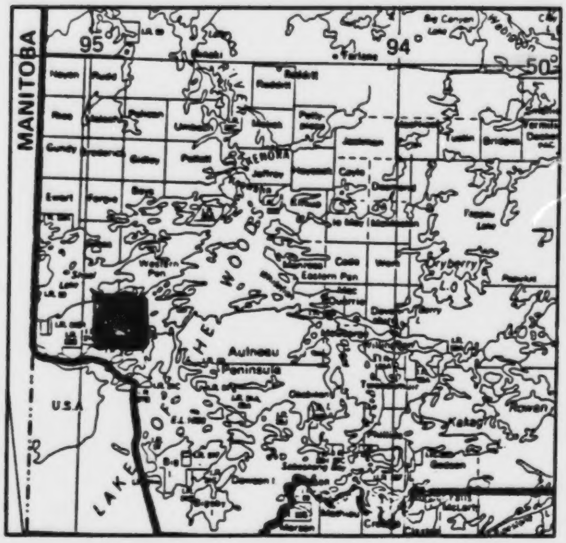
MANITOBA
95°
94°
50°
KENORA
Aulneau
Peninsula
U.S.A.
LAKE OF THE WOODS
LOCATION MAP
Scale : 1:1 584 000 or
1 inch to 25 miles

FIGURE 1: Location map

Geology of the Monument Bay Area, Lake of the Woods, District of Kenora

ABSTRACT

The Monument Bay area encompasses about 150 km^2 in the District of Kenora, about 50 km southwest of the Town of Kenora. The area is part of the Lake of the Woods greenstone belt, an east-west trending belt of metavolcanic-metasedimentary rocks which is located in the western part of the Wabigoon Subprovince of the Superior Province of the Canadian Shield. The area is bounded by Latitudes 49°30′N and 49°22′N and Longitudes 94°56′W and 94°47.7′. All bedrock in the map area is inferred to be Archaean in age, with the exception of northwest-trending Proterozoic diabase dikes.

Lithologies face south in the north half of the map area while, several reversals in the south part define tight folds. Most supracrustal lithologies have a well developed foliation which trend east to northeast except where deflected around granitic plutons. Intensity of fabric development is heterogeneous.

Ninety percent of the map area is underlain by metavolcanics, 5% by metasediments and 5% by granitoids. The metavolcanics have been subdivided, both on textural and geochemical criteria, into alkalic and subalkalic associations. Alkalic metavolcanics comprise about 80% of the metavolcanics with lithologies ranging in composition from mafic to felsic. The remaining 20% of metavolcanics are subalkalic basaltic komatiites and basalts. Alkalic basalts are mainly pyroclastic; individual clasts may be highly amygdaloidal and characteristically contain euhedral

calcic clinopyroxene phenocrysts (now largely pseudomorphed by amphibole). Subalkalic basalts are invariably pillowed or massive flows, are non- to weakly vesicular, aphyric and commonly variolitic. Geochemistry supports distinctiveness of these textural features. Alkalic basalts ($SiO_2<53\%$) have high K_2O contents ($K_2O>1\%$) and light-enriched rare earth element (REE) patterns ($(Ce/Yb)_N>5$). On the other hand, subalkalic basalts are low in K_2O ($K_2O<0.3\%$) and have flat to slightly light-depleted REE patterns ($(Ce/Yb)_N<1.5$).

Metasediments occur as conglomerates, produced by local reworking of pyroclastics, interflow argillites and siltstones and several wacke horizons.

Intrusive rocks are synvolcanic mafic to felsic sills, a suite of pre-metamorphic alkalic intrusive rocks including lamprophyre dikes and a syenite and two late tectonic granodiorite plutons in the north part of the map area.

The supracrustal rocks have been altered to varying degrees with two types of alteration are especially significant. Two zones of hornblende ± garnet alteration trend northeast across the map area within amphibolite grade assemblages. In greenschist facies terrain the equivalent alteration is manifest as carbonatization.

While there is no known mineral production from the map area, several features make this an attractive area in which to conduct mineral exploration. The areas with the most potential for base metal exploration are proximal quartz-phyric intermediate to felsic metavolcanics, especially west of Outer Bay where massive

sulphide clasts are associated with the metavolcanics. Gold exploration should be directed primarily at shear zones within mafic metavolcanics of the Cochrane Island and Separation Point formations, and in the region of extensive hornblende ± garnet and carbonate alteration. The amphibolite-greenschist facies boundary crosses both trends at near right angles and should direct initial exploration. A number of samples collected from quartz-carbonate-sulphide veins in shear zones in the mafic metavolcanics contain >100 ppb gold with the highest value being 52.3 ppm gold.

GEOLOGY

# of the

MONUMENT BAY AREA

LAKE OF THE WOODS

DISTRICT OF KENORA

by

M.G.MORRICE

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Drafting: K.Gil.

INTRODUCTION

Location

Field investigations in 1987 represent the second year of a geological mapping project in the southwestern part of Lake of the Woods initiated to complete the 1 inch to 1/4 mile (1:15,840) geological map base of the Lake of the Woods greenstone belt. An area of about 150 km^2 was mapped at a scale of 1:15,840. This area is bounded by Latitudes $49^{o}30'$N and $49^{o}22'$N and Longitudes $94^{o}56'$W and $94^{o}47.7'$W (Fig.1). The Towns of Kenora, Ontario and Angle Inlet, Minnesota are located 50 km northeast and 20 km southwest, respectively, of the centre of the map area.

MEANS OF ACCESS

The map area is accessible by boat from either Kenora or Angle Inlet. The northwestern portion of the map area was accessed by canoe from Mason and Reid Lakes.

Except for areas underlain by granitic rocks, rocks in the bush generally are poorly exposed due to a ubiquitous, though uneven, veneer of sandy till. Exposures along the shoreline of Lake of the Woods are excellent. During the 1987 field season the water level on Lake of the Woods was about one metre below normal levels. This resulted in the exposure of many normally inundated outcrops.

Physiography

Elevations in the map area, as taken from 1:50,000 topographic maps published by the Surveys and Mapping Branch, Federal Department of Energy, Mines and Resources (Falcon Island (NTS 52E7)) range from 373 metres above sea level, southeast of Reid Lake, to 323 metres above sea level, the elevation of the mean water level on Lake of the Woods. Relief, generally less than 15 metres but locally, as at Reid Lake, is as much as 50 metres.

Most outcrops in the bush form isolated hills which rise about 5-20 metres above intervening flat Pleistocene and Recent plain deposits while shoreline outcrops are generally low and flat steep sided cliffs characterize shoreline exposures in Laser Bay, the S-shaped bay off the north side of Monument Bay, north of Cochrane Island.

Bedrock lithology and structure have only a slight influence on topography noted by linear ridges and valleys and elongate islands and chains of islands.

In general, drainage is poorly developed in the map area. Mason and Reid Lakes, drain south into Lake of the Woods.

Field Methods

Mapping was carried out by examining outcrop along the shore of Lake of the Woods and by pace and compass traverses inland. Zig-zag traverses were run between outcrops located on aerial photographs. No large outcrops, and only a few small outcrops were missed.

Geological data were plotted in the field on acetate sheets attached to aerial photographs at a scale of 1:15,840. The data were subsequently transferred to cronaflex base maps, scale-corrected to 1:15,840, which had been prepared from OBM base maps by the Cartography Section of the Ontario Ministry of Natural Resources.

Previous Geological Work

The first recorded geological descriptions of the Lake of the Woods greenstone belt were the result of a reconnaisance survey made in 1883, 1884 and 1885 by Lawson (1885) who examined outcrops in the eastern part of the map area. During the period from 1893 to 1910, numerous gold deposits were discovered and subsequently exploited in the northern part of Shoal Lake, north of the present map area. In 1929 (1931), Greer examined outcrops in the north part of the map area as part of a geological mapping program on Shoal Lake.

The Monument Bay map area adjoins the Western Peninsula map sheet (Davies, 1983) to the north and the Northwest Angle Inlet sheet to the west (Morrice and MacMaster, 1987).

Mining and Exploration History

Despite several periods of intense exploration and mining activity in the northern part of Lake of the Woods greenstone belt, there is no record of mining activity and very little in the way of recorded information concerning exploration activity in the Monument Bay map area. The activity in the north part of the lake focussed on gold in the 1880's to the early 1900's, in the 1930's to 1940's, and from the mid 1970's to the present. Base metal exploration activity peaked in the 1960's to 1970's.

In the present map area, there are no confirmed records of historic gold exploration.

Base metal (Zn, Cu) exploration was carried out during the early to mid-1970's by Hudson Bay Exploration and Development Co. Limited and Phelps Dodge Corporation of Canada Limited in the central and northern part of the map area.

Acknowledgements

Capable assistance in the field was provided by G.A.MacMaster, K.Cook, H.Charbonneau and H.Douglas. MacMaster, as senior assistant, was responsible for approximately 50% of the mapping.

Charbonneau undertook a BSc thesis at the University of Western Ontario on the hydrothermal alteration of alkalic pillowed intermediate metavolcanics of the Johnston Passage formation. Her contribution to the understanding of this amphibolite facies alteration is gratefully acknowledged.

Thanks are also extended to S.Buck who helped with the structural geology of the Monument Bay Deformation Zone.

This project is part of the Canada-Ontario Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario.

GENERAL GEOLOGY

Introduction

The Monument Bay area is underlain by an east- to northeast-trending sequence of Archean metavolcanic and metasedimentary rocks (Figs. 2). These supracrustal rocks have been intruded by Archean syn- to post-tectonic granitic and syenitic plutons, and north-northwest-trending Proterozoic diabase dikes (Table 1).

Supracrustal rocks underlie approximately 90% of the Monument Bay area; igneous plutonic rocks underlie the remaining 10%. Supracrustal rocks are mainly metavolcanic and range in composition from ultramafic to felsic. Metasediments comprise about 5% of the supracrustal rocks. On the basis of field observations and geochemical data from the adjoining Northwest Angle Inlet map area two distinct geochemical packages are recognized in the Monument Bay and Northwest Angle Inlet map areas. An alkalic (shoshonitic) to calc-alkalic association comprises about 80% of the metavolcanics with lithologies ranging in composition from mafic to felsic. The remaining 20% of metavolcanics are subalkalic basaltic komatiites and basalts. These two associations are readily distinguishable in the field. Alkalic basaltic rocks are predominantly clastic; individual clasts commonly are highly amygdaloidal and characteristically contain euhedral calcic clinopyroxene phenocrysts (now largely pseudomorphed by amphibole). Subalkalic basalts are invariably pillowed or massive flows, are non to weakly vesicular, aphyric and commonly variolitic. These distinct megascopic features are supported by geochemistry. Alkalic basalts (SiO_2 <53%) have elevated K_2O contents (K_2O>1%) and light-enriched REE patterns ($(Ce/Yb)_N$>5). On the other hand, subalkalic basalts are low in K_2O (K_2O<0.3%) and have flat to slightly light-depleted REE patterns ($(Ce/Yb)_N$<1.5). The alkalic and subalkalic metavolcanics are interlayered and appear to form a conformable sequence*.

The supracrustal rocks of the Monument Bay map area have been subdivided into 15 formations, on the basis of distinct field and textural characteristics (Fig. 4) (Table 2). This lithostratigraphic subdivision is tentative and probably will be changed by mappers in the future after the completion of the detailed mapping of the Lake of the Woods Greenstone Belt. With the exception of the subalkalic Cochrane Island and Partridge Lake Formations and the metasedimentary Long Island, Royal Island, Betty Island and Burnt Island Formations, all of these are composed entirely or mainly of alkalic-calcalkalic metavolcanics.

---

* Note of caution by the reviewers of this report (1988): More recent geochemical investigations on rock samples obtained from areas not to substantiate the results presented here and more geochemical work is needed on rocks the from Lake of the Woods Greenstone Belt to substantiate the presence or absence of large quantities of alkalic rocks.

Subalkalic mafic to ultramafic metavolcanics (Unit 1), mainly pillowed and massive basaltic and basaltic komatiite flows, are the main lithologies of the Partridge Lake and Cochrane Island formations, but also occur as mappable units within the South Bay, Separation Point, Clipper Island and Drift Island formations. Alkalic to calc-alkalic mafic metavolcanics are abundant in the Monument Bay, Separation Point, South Bay and Clipper Island formations. Alkalic to calcalkalic intermediate metavolcanics occur within the Johnston Passage and Separation Point formations. The Mason Lake, La Vérendrye Island, and Drift Island formations are underlain mainly by alkalic to calc alkalic intermediate-felsic metavolcanics.

The volcanic sequence in the Monument Bay map area is estimated to be 10 km thick. The stratigraphic base is the mafic metavolcanics of the Partridge Lake formation. The top of the stratigraphic succession is placed at the uppermost intermediate flows in the Johnstone Passage formation. The general stratigraphic evolution is from mafic to felsic with increasing startigraphic elevation. Several thin horizons of epiclastic metasediments occur interbedded with metavolcanics near the top of the entire sequence. Repetition of units by folding and/or faulting is suspected in the southern part of the map area, where facing directions are poorly preserved.

Prior to metamorphism and deformation the volcanic-sedimentary sequence was intruded by many synvolcanic sills.

These sills range in composition from ultramafic to felsic and comprise less than 5% of the stratigraphic sequence. Individual sills are generally less than 100 metres thick.

A suite of compositionally and texturally diverse lamprophyre dikes were emplaced into the volcanic-sedimentary sequence prior to metamorphism and deformation. These dykes range in width from less than 5 cm to about 100 m and in composition from monzodiorite to biotite hornblendite. These intrusions are volumetrically minor (<1%) but are ubiquitous throughout the map area.

A syenite border phase of the Falcon Island Igneous Complex (FIIC) is exposed in the southeastern part of the map area. Lamprophyre dikes intrude ultramafic phases of the FIIC, immediately southeast of the map area indicating that the FIIC either predates or is synchronous with lamprophyre dike emplacement.

Syn- to late-tectonic felsic igneous activity resulted in the emplacement of the Mason Lake and Outer Bay hornblende-biotite granodiorite plutons.

The volcanic-sedimentary sequence was metamorphosed under greenschist and amphibolite facies conditions. The amphibolite-greenschist isograd trends approximately east-west across the north part of the map area. The amphibolite facies metamorphism is a broad contact aureole related to the Sabaskong Batholith, located south of the Monument Bay map area (Blackburn, 1981).

The last igneous event was the emplacement of north-northwest-trending Proterozoic diabase dikes.

Metavolcanics-Metasedimentary Rocks

Subvolcanic Metavolcanics

Mafic to Ultramafic Metavolcanics (Unit 1)

Subalkalic mafic and ultramafic metavolcanics comprise two formations (Partridge Lake, and Cochrane Island), occur as mappable units in two formations (South Bay and Clipper Island) and as thin interbedded flows in two formations (Separation Point and Drift Island) (Fig.4). They represent basaltic and basaltic komatiite flows metamorphosed under amphibolite and greenschist facies conditions. On weathered surfaces, ultramafic metavolcanics weather light to medium green while mafic metavolcanics weather black to dark green. The colour of both becomes lighter with decreasing metamorphic grade. On fresh surfaces, ultramafic metavolcanics are medium to dark green, and mafic metavolcanics are black to dark green. Both the mafic and ultramafic metavolcanics range from being well foliated to massive.

Subalkalic mafic and ultramafic metavolcanics are non to sparsely vesicular, mainly aphyric flows. Plagioclase-phyric flows are found in the Clipper Island formation with plagioclase phenocrysts ranging in size from 1 to 5 mm and in abundance up to 25%. Minor, but conspicuous, equant plagioclase phenocrysts, up to 1 cm in diameter, are also present in mafic metavolcanics in the Partridge Lake, Cochrane Island and Separation Point formations. These plagioclase-megacrystic flows or "leopard rocks" resemble leopard rock flows which are conspicuous in the Lower Mafic group, elsewhere on Lake of the Woods (eg. Ayer et al, 1985). In the Monument Bay area the interlayering of "leopard rocks" with alkalic metavolcanics within the Upper Diverse group demonstrates that leopard rocks are not restricted to the Lower Mafic Group in the Lake of the Woods area (cf. Wilson, et al, 1974; Ayer and Sweeney, 1986; Ayer and Gil, 1986; Ayer et al, 1985).

Individual flows 5 to 25 metres thick occur as simple or compound flow units. Most simple flows are pillowed and are either mafic or ultramafic in composition (Photo 1). Simple massive flows are rare and tend to be mafic in composition. Compound flows are common and are characterized by massive mafic bases overlain by pillowed ultramafic tops. The mafic-ultramafic transition is gradational over 1-2 metres near the top of the massive portion of the flow. The massive mafic bases are medium to coarse grained; many contain conspicuous 0.5-10 cm long dendritic pyroxene crystals (pseudomorphed by amphibole). Simple pillowed and compound flows are invariably variolitic with 2-20 mm diameter light coloured varioles concentrated near the tops of massive flows and near selvages in pillowed flows. Massive mafic flows are typically medium grained, weather dark green to black and contain 40-70% black hornblende. This contrasts with pillowed ultramafic flows which are fine grained, commonly variolitic, weather light green and are composed of 60-95% light green amphibole (tremolite-actinolite). Individual pillows are 0.5-1.0 metres long, have 0.5-1.0 cm wide selvages and may be associated with pillow breccia.

Ultramafic metavolcanics are composed of 65-75% pale green tremolite-actinolite and subordinate plagioclase (20-30%). Ultramafic metavolcanics metamorphosed under greenschist facies conditions contain 20-40% chlorite, 30-50% tremolite-actinolite and 20-30% plagioclase. Opaque minerals (<2%) are finely disseminated. Primary igneous textures, indicative of rapid crystallization due to supercooling, are preserved as dendritic clinopyroxene crystals, now pseudomorphed by amphibole.

Mafic metavolcanics contain 35-50% plagioclase and 50-60% amphibole, which is deep blue-green hornblende in amphibolite facies rocks and pale green actinolite in greenschist facies rocks. Minor mineral phases in both mafic and ultramafic metavolcanics include epidote, quartz, calcite and opaque minerals.

The polarity of the compound flows, as defined by their mafic bases and ultramafic tops is opposite to what would be expected if crystal-liquid processes, involving settling of high temperature Fe-Mg mineral phases, were operative. The lack of phenocrysts in these flows suggests that this polarity is due to liquid-liquid processes, possibly analogous to mixed komatiitic lavas from Munro Township (Arndt and Nesbitt, 1984). The polarity of these flows can be explained by the injection of an ultramafic liquid into the bottom of a magma chamber dominated by mafic liquids thereby triggering an eruption, with the mafic liquids erupting first and subsequently followed by ultramafic liquids.

The subalkalic basalts and basaltic komatiites of the Cochrane Island formation are intruded by synvolcanic mafic (Unit 7) and intermediate-felsic (Unit 8) sills.

ALKALIC TO CALC-ALKALIC METAVOLCANICS

Mafic Metavolcanics (Unit 2)

Alkalic mafic metavolcanics are the main lithologies in the Monument Bay, Separation Point, South Bay and East Windigo Island formations and comprise a significant proportion of the Clipper Island Formation (Fig.3). Weathered surfaces vary from medium to dark grey (amphibolite facies grade) to medium to dark green (greenschist facies grade); fresh surfaces are dark grey to dark green. Alkalic mafic metavolcanics which have been metamorphosed to amphibolite grade are biotite-bearing resulting in a characteristic sheen to outcrop surfaces in sunlight. Alkalic mafic metavolcanics range from massive to well foliated.

Alkalic mafic metavolcanics occur as pyroclastic rocks in the Separation Point, South Bay, Clipper Island and East Windigo Island formations. The Monument Bay formation is composed of approximately equal proportions of flows and pyroclastics. The flows occur mainly in the north (base of the formation) while pyroclastics are abundant in the south (top of the formation). Alkalic mafic metavolcanics are interbedded with alkalic intermediate-felsic pyroclastics in the Monument Bay and Clipper Island formations, with subalkalic intermediate flows and pyroclastics in the Separation Point formation and with subalkalic mafic flows in the South Bay formation.

The most striking textural feature of the alkalic mafic metavolcanics is the presence of equant, 0.2- 1.0 cm diameter, euhedral calcic clinopyroxene phenocrysts (now largely pseudomorphed by amphibole and biotite) (Photo 2); ranging in abundance from 0 to 40%. Calcic clinopyroxene phenocrysts have been documented in various stages of degradation in the Monument Bay and Northwest Angle Inlet area to the west (Morrice and MacMaster, 1987). Fresh oscillatory and sector-zoned clinopyroxene phenocrysts occur in massive flows in the Mackay Island area of Shoal Lake (Morrice and MacMaster, 1987). With increasing grade of metamorphism these clinopyroxene phenocrysts are pseudomorphed by actinolite and hornblende. With increasing deformation the clinopyroxene phenocrysts are flattened and altered to biotite. Where deformation is particularly severe, as in the Monument Bay Deformation Zone, all that remain of the original clinopyroxene phenocrysts are thin biotite wisps or discs (0.2-0.5x5-10 mm), flattened in the plane of foliation (Photo 3).

Many of the mafic alkalic metavolcanics are also plagioclase-phyric with phenocrysts ranging in abundance from less than 1% to about 20%. The morphology of these phenocrysts is very distinctive with very slender, tabular crystals having length:width ratios of about 5:1 (Photo 4). They range in length from about 3 mm to 2.5 cm and all are variably saussuritized. Flows and clasts within pyroclastic deposits are commonly amygdaloidal, with up to 50% calcite and/or quartz-filled amygdules which range in size from less than 1 mm to 5-10 cm.

North of Monument Bay, at the base of the Monument Bay formation, a laterally persistent horizon of clinopyroxene-phyric, amygdaloidal, pillow and massive basalt has been traced for 12 km along strike, decreasing in thickness from 1 km in the Northwest Angle Inlet area (Morrice and MacMaster, 1987) to 30 m near Picture Rock Point. This unit contains 10-25% clinopyroxene phenocrysts, mostly altered to biotite, and 5-40% calcite-filled amygdules. Pillows are large (up to 2-3 m in diameter) and selvages are thick (3-5 cm). A similar unit occurs 1.5 km to the south of this horizon.

The alkalic mafic units which underlie the south half of the Monument Bay, the Separation Point, and the East Windigo Island formations are composed mainly of tuff breccia, lapilli tuff, and tuff, with lesser pillowed and massive flows. Pillows are similar to those which occur in the pillowed unit at the base of the Monument Bay formation. Massive flows are blocky characterized by clinopyroxene-phyric autoclastic breccias (Photo 5). Bedding is well developed in the pyroclastics and ranges in thickness from less than 1 cm (tuffs) to greater than 2 metres (tuff breccias) (Photo 6). Coarse pyroclastics range from matrix to clast supported. All three formations are characterized by monolithic pyroclastics containing abundant scoria clasts. Bomb sags and coarse and diffusely bedded tuffs suggest proximal deposition in a shallow water or subaerial environment (Fisher and Schmincke, 1984, Williams and McBirney, 1979) (Photo 7). Cross bedding and scour features may have formed from pyroclastic surges associated with phreatomagmatic volcanic activity (Photo

8) (eg. Fisher and Schminke, 1984). As little or no reworking is evident, these deposits are interpreted to be primary pyroclastics deposited in a series of locally emergent cinder cones.

Alkalic mafic metavolcanics in the South Bay area are predominantly heterolithic pyroclastics interbedded with subordinate subalkalic mafic and intermediate flows. The alkalic rocks are well bedded (<1 metre to several metres thick beds) debris flows comprised of varying proportions of mafic and intermediate clasts. Clinopyroxene phenocrysts occur in both mafic and intermediate clasts as well as comprising a significant, but variable, matrix component. Many of the intermediate clasts are aphyric or plagioclase-phyric.

The most diagnostic metamorphic mineral of the alkalic mafic metavolcanics at amphibolite facies is biotite which occurs scattered through the matrix and as reaction rims on or wholly replacing pseudomorphed clinopyroxene phenocrysts. The presence of biotite is due to reaction of unstable potassium-bearing groundmass phases (sanidine?) with ferromagnesian components in the rock (cf. Brooks et al, 1982); that is, this "biotitization" is not due to potash metasomatism.

All clinopyroxene, except for phenocrysts from a porphyritic sill in the Mason Lake formation, have been replaced by metamorphic hydration products (amphibole, biotite). At amphibolite facies grade these are hornblende and biotite while at greenschist facies grade, clinopyroxene is pseudomorphed by actinolite, biotite and carbonate. Additional groundmass phases include epidote and opaque minerals. Carbonate is much more abundant in lower metamorphic grade rocks.

Intermediate Metavolcanics (Unit 3)

Alkalic-calc alkalic intermediate metavolcanics occur as plagioclase-phyric flows and to a lesser extent pyroclastics in the Separation Point and Johnston Passage formations (Fig. 3). Weathered surfaces are light grey; fresh surfaces are light to medium grey. These intermediate metavolcanics range from massive to well-foliated. Alkalic-calc alkalic intermediate metavolcanics are also found as aphyric and plagioclase-phyric clasts comprising a minor component of heterolithic mafic (Unit 2) and intermediate-felsic (Unit 4) pyroclastics in the Mason Lake, Monument Bay, South Bay, Separation Point, La Verendrye Island and Drift Island formations.

Flow units are composed of pillows and pillow breccia distinct from subalkalic intermediate metavolcanics, containing 10-25%, 2-5 mm long, tabular plagioclase phenocrysts in a vesicular (10-25% calcite and quartz-filled amygdules) groundmass. The plagioclase phenocrysts have slender, tabular morphologies, similar to those described previously from alkalic mafic metavolcanics. Pillows are 0.5-1 m X 0.25-0.5 m and characterized by 2-5 cm thick selvages. Pillow breccias are especially abundant in the Johnstone Passage formation (Photo 9). Individual flows are 5-10 metres thick and are interbedded with both coarse and fine pyroclastics.

Intermediate pyroclastics are poorly sorted, matrix-supported deposits that are well-bedded with bedding thickness ranging from less than 20 cm to greater than 4 metres. They are interpreted to be debris flows on the basis of their poorly sorted and heterolithic nature

Plagioclase phenocrysts are in varying stages of alteration to saussurite. The groundmass of individual clasts is characterized by a fine-grained mosaic of quartz and feldspar with 10-25% biotite and 5-15% hornblende. Accessory phases include epidote, carbonate and opaque minerals.

Intermediate clasts within pyroclastic deposits contain 0.5-2 cm size hornblende and/or biotite aggregates. As in the case of the clinopyroxene phenocrysts, these inclusions were observed in various stages of degradation from pseudomorphosed clinopyroxene crystal aggregates to flattened biotite wisps. These are especially evident in clasts in the South Bay formation. where they are interpreted to be accumulations of clinopyroxene crystals which were incorporated into the host intermediate magma in the magma chamber or during magma ascent such inclusions are common in Cenozoic volcanics (eg. Arculus and Wills, 1980). With increasing metamorphism and deformation, the clinopyroxenes are first pseudomorphed by hornblende which is in turn replaced by biotite, as was documented for the clinopyroxene phenocrysts of the alkalic mafic metavolcanics.

Intermediate to Felsic Metavolcanics (Unit 4)

Alkalic to calc alkalic intermediate-felsic metavolcanics the main compositions present in the Mason Lake, La Vérendrye Island, and Drift Island formations in the lower half of the Monument Bay formation (Fig. 3). Heterolithic pyroclastics predominate and synvolcanic sills are abundant in the Drift Island formation. Weathered and fresh surfaces are light grey to buff. Intermediate-felsic metavolcanics range from massive to well foliated.

Intermediate to felsic metavolcanics consist of heterolithic tuff breccia, lapilli tuff and tuff with monolithic pyroclastics being less abundant in the Mason Lake and Drift Island formations. Plagioclase-phyric (5-30%, 1-3mm equant plagioclase phenocrysts) and lesser aphyric clasts are common in intermediate to felsic pyroclastics in the Mason Lake, Monument Bay and Drift Island Formations. Felsic clasts within the intermediate-felsic pyroclastics in the La Verendrye Island formation are mainly aphyric.

Individual pyroclastic heterolithic deposits are poorly sorted, clast-supported and thickly bedded. They are interpreted by the author on the basis of their poorly sorted and heterolithic nature to have been deposited as debris flows. Local reworking of these debris flows is evident in the Monument Bay formation where conglomerates, with well rounded cobbles of aphyric intermediate-felsic volcanics, are interbedded with debris flows and feldspathic wackes (Photo 14). Quartz + plagioclase-phyric clasts occur in discrete monolithic to heterolithic pyroclastics west of Outer Bay in the Mason Lake formation and west of Falcon Island in the Drift Island formation.

In the Mason Lake Formation quartz + plagioclase-phyric clasts occur in monolithic tuff breccias which also contain minor cm-size massive sulphide (pyrrhotite, pyrite) clasts. These pyroclastics grade laterally into heterolithic tuff breccias, suggesting lateral reworking of the brecciated carapace of a felsic dome. The sulphide clasts may have been incorporated from reworked exhalative massive sulphide deposits associated with the dome. In the Drift Island formation quartz + plagioclase-phyric clasts which occur in pyroclastic deposits have similar textures to massive quartz-plagioclase porphyry units which occur throughout this formation. This suggests a cogenetic link between quartz - plagioclase - phyric clasts and massive quartz - plagioclase porphyry units. However, it is not clear whether these massive porphyries are flows that have supplied detritus to felsic pyroclastics or are simply synvolcanic sills.

Well-bedded intermediate-felsic tuffs are minor but ubiquitous within all intermediate-felsic formations. Bedding ranges in thickness from 1 mm to greater than 1 m.

Quartz phenocrysts are deeply embayed, indicating resorption by surrounding magma. Plagioclase phenocrysts are equant to lathlike and in varying stages of saussuritization. The oscillatory zoning is typical of plagioclase phenocrysts formed in a volcanic environment, and indicates crystal growth in shallow level magma chambers (eg. Gill, 1981) many are oscillatory zoned. The groundmass of porphyritic clasts is composed of a fine grained quartz-feldspar mosaic with minor biotite, sericite, carbonate and opaque minerals. The matrix to the clasts contains 5-15% biotite and minor amphibole. Chlorite occurs in intermediate-felsic metavolcanics metamorphosed under greenschist facies.

Clastic and Chemical Metasediments (Unit 5)

In the map area metasediments occur as conglomerates and associated wackes formed by local reworking of debris flows and tuffs in the Monument Bay formation, as fine-grained interflow metasediments in the Cochrane Island formation, and as laterally persistent horizons of wackes, with lesser iron formation in the southeast half of the map area (Royal Island, Long Island, Betty Island Burnt Island formations) (Figs. 3,4). Outcrops of conglomerates weather light buff, interflow metasediments weather medium grey-green and wacke weathers light to medium grey. Metasediments range from massive to well foliated.

In the Monument Bay formation reworking of heterolithic debris flows has produced localized clast-supported conglomerates from Monument Bay to Outer Bay. These conglomerates are characterized by rounded to well-rounded 2-20 cm diameter clasts, of aphyric intermediate-felsic metavolcanics mixed with a variety similar size of angular to subangular, metavolcanic clasts that include mafic clinopyroxene-phyric clasts. The matrix is mainly a metamorphosed immature plagioclase wacke. Hornblende and biotite are metamorphic products of the clay-size fraction. These conglomerates are interbedded with volcanically derived feldspathic wacke and heterolithic debris flows. They are interpreted to represent local fluvial reworking of debris flows on the flank of a volcano. These conglomerates occur within a confined interval in the volcanic stratigraphy and may have been deposited during a temporary cessation of volcanism.

Thinly bedded argillaceous interflow metasediments are associated with subalkalic massive and pillowed flows in the Cochrane Island formation. Bedding is well developed and very delicate, suggestive of quiet water deposition. Individual beds are less than 1 mm to about 10 cm thick. Local soft sediment deformation occurs northeast of Separation Point.

The most widespread types of metasediments are wacke with lesser iron formation associated with alkalic intermediate-felsic metavolcanics in the south half of the map area. Four wacke units (Royal Island, Long Island, Betty Island, Burnt Island formations) are recognized and there is the distinct possibility of repetition of one or more of these units due to folding or faulting. Wacke horizons are composed mainly of thick-bedded quartz-feldspar wacke with AE Bouma sequences (Photo 10). Bed thickness averages 0.5-1.5 m, with the basal "A" division being 0.4-1.2 m thick and the upper, pelitic, "E" division making up the remaining 0.1-0.2 m of the bed. These wackes resemble the Warclub group of metasediments on the east side of Lake of the Woods (Glen Johns, geologist, Ontario Geological Survey, personal communication, 1987). Several of the wacke beds contain ball and pillow structures defined by 3-5 cm diameter balls of sand-size material within the upper pelitic portion of the bed. Iron formation occurs within the Betty Island formation, and is particularly well developed near the east edge of the map area, where metachert and meta-ironstone are interbedded with wacke. Bedding within the iron formation is less than 1 cm to 30 cm thick and highly contorted, possibly the result, at least in part, of soft sediment slumping.

Recrystallization has obscured primary mineralogy in all of the metasediments, except in the conglomerates and feldspathic wackes in Outer Bay. Where primary mineralogy is preserved, the wackes are characterized by abundant broken plagioclase crystals. The groundmass is a fine-grained, mainly recrystallized granoblastic mosaic of quartz and feldspar grains with lesser biotite and chlorite. The thick-bedded wackes of the south part of the map area have been recrystallized and are now characterized by the presence of garnet, staurulite and andalusite. Most conspicuous among these are 1-3 cm diameter knots of seive-textured andalusite which contain tiny inclusions of epidote, quartz, feldspar, and garnet (Photo 16). In some wackes the andalusite porphyroblasts have retrograded to aggregates of quartz, plagioclase, muscovite and chlorite. Other porphyroblasts are garnet and staurolite. Biotite is ubiquitous, in amounts ranging between 15 and 25%.

Intrusive Rocks

Metamorphosed Ultramafic Intrusions (Unit 6)

Metamorphosed ultramafic intrusive rocks are confined to small occurrences in the Separation Point Cochrane Island and Clipper Island formations (Fig. 3). They are comprised of metamorphosed pyroxenites that weather a medium to dark green colour and range from massive to schistose. Both the pyroxenites and gabbros with which they are associated contain 0.5-1 cm diameter clinopyroxene crystals. This suggests that the pyroxenites are basal cumulate portions of layered mafic-ultramafic sills. The marked similarity between the clinopyroxene crystals and clinopyroxene phenocrysts in adjacent mafic volcanics is consistent with these sills being subvolcanic intrusions.

The ultramafic sills are 20-80 m thick. They are composed mainly of light green amphibole (75-90%), serpentine and lesser biotite, plagioclase and opaque minerals.

Metamorphosed Mafic Intrusions (Unit 7)

Metamorphosed mafic intrusive rocks are interpreted by the author to represent synvolcanic sills. They are most abundant in the Cochrane Island formation, but also occur within the Separation Point and Clipper Island formations (Fig. 3). Both weathered and fresh surfaces are black. These mafic intrusive rocks are invariably massive and non-foliated; deformation is taken up along their margins or in narrow (<1 m wide), discrete internal shear zones.

Individual intrusions, which tend to be sill-like, range in thickness from less than 1 m to 350 m; most are less than 100 m thick. Colour indices range between 35 and 65 and textures range from medium grained equigranular to inequigranular. Mafic sills are composed mainly of amphibole and plagioclase with accessory opaque minerals, epidote and carbonate. Porphyritic varieties contain 2-5 mm clinopyroxene phenocrysts (pseudomorphed by hornblende) in a finer-grained groundmass. Many of the units mapped as mafic sills within the Cochrane Island formation may be coarse grained massive mafic flows.

Metamorphosed Intermediate-Felsic Intrusions (Unit 8)

Metamorphosed, intermediate-felsic plagioclase and quartz-plagioclase porphyry sills <1 to 40 m wide occur throughout the map area with the greatest proportion occurring in the Drift Island formation (Fig. 3). On the basis of textural similarity to clasts in spatially related pyroclastics metavolcanics they are interpreted to be synvolcanic. Some of the units mapped as sills may be flows. They range from massive to well foliated weathered and fresh surfaces are light grey to buff.

Feldspar porphyry sills contain 10-30%, 2-4 mm size, equant plagioclase phenocrysts in a fine grained mosaic of quartz, plagioclase with minor biotite and opaque minerals. In addition to the plagioclase phenocrysts, quartz-feldspar porphyry sills contain 5-15%, 2-5 mm diameter, embayed, quartz phenocrysts. Tiny needles of sillimanite occur in a feldspar porphyry sill at the northeast end of the La Vérendrye Island formation.

Alkalic Intrusive Rocks (Unit 10)

A microcline-phyric hornblende syenite, which is a border phase of the Falcon Island Igneous Complex, intrudes intermediate-felsic metavolcanics and metasediments in the southeast part of the map area (Photo 11). The Falcon Island Igneous Complex is a 10 km diameter, highly magnetic, intermediate-ultramafic alkalic intrusion, the core of which lies to the east of the Monument Bay map area (Blackburn, 1981; ODM-GSC, 1962). The syenite border phase in the Monument Bay map area has a pronounced igneous foliation, defined by the alignment of tabular microcline phenocrysts, which trends parallel to its outer contact. The syenite is characterized by 40-60%, 1-2 cm long, microcline phenocrysts in a groundmass composed mainly of deep green hornblende and biotite. Clinopyroxene occurs as minor ragged cores to some hornblende crystals. Accessory phases are apatite, titanite and muscovite.

A suite of massive to foliated biotite-bearing lamprophyre dikes occurs throughout the map area. Their greatest concentration is within and adjacent to the subalkalic metavolcanics passing through Cochrane Island. The lamprophyres range in composition from monzodiorite to hornblendite and in texture from fine to coarse grained, equigranular to hornblende-phyric to pegmatitic. Individual intrusions range from dikelets, less than 5 cm wide, to multiphase intrusions, up to 100 m wide. Several of these lamprophyres are associated with chaotically brecciated country rock. This brecciation is interpreted to have been caused by hydrofracturing of roof rocks by volatiles exsolved during lamprophyre emplacement.

Texturally, lamprophyres comprise a diverse suite of fine- to medium-grained equigranular to porphyritic rocks. Porphyritic phases of lamprophyres are characterized by equant, cm-size clinopyroxene phenocrysts which have been pseudomorphed by hornblende. Texturally, they resemble clinopyroxene-phyric mafic alkalic metavolcanics. One fine-grained lamprophyre, from the Separation Point formation, is composed of 60% plagioclase laths, 30-35% biotite, 10-15% hornblende, 3% pyrite and 3-5% carbonate. This rock has an unusual texture, characterized by 1-8 mm diameter ocelli comprised of plagioclase laths.

Intermediate to Felsic Intrusive Rocks (Unit 9)

Intermediate-felsic intrusive rocks occur in two distinct plutons and several smaller dike-like bodies in north part of the Monument Bay map area. All are composed mainly of medium- to coarse-grained inequigranular to microcline megacrystic hornblende-biotite granodiorite with lesser hornblende diorite and quartz diorite (Figs. 4,5). A weak fabric, defined by alignment of mafic xenoliths and microcline megacrysts, occurs within these granodiorites along and parallel with their margins indicating fabric development during pluton emplacement. The plutons are characterized by the presence of minor, 5-15 cm x 2-5 cm, fine-grained amphibolite xenoliths.

The Mason Lake and Outer Bay plutons are texturally distinct from each other. The Mason Lake pluton has an inequigranular to quartz-phyric texture characterized by cm-size quartz grains in a medium- to coarse- grained granitic groundmass. There is little or no evidence of wall-rock assimilation along the margins of the Mason Lake granodiorite. The Outer Bay pluton contains 5-35%, 0.5-1.5 cm size. microcline megacrysts in a medium-grained granitic groundmass. Hornblende diorite and quartz diorite phases occur along the south margin of the Outer Bay intrusion, indicating local wall rock assimilation. 0.25-1 km wide epidote-hornblende hornfels contact metamorphic aureoles have developed in country rocks adjacent to both these intrusions.

Minor granodiorite, quartz diorite and diorite dikes, 1-100 m wide, intrude and crosscut foliation in the metavolcanics. Pegmatite and aplite intrusions characterize the contact zones of the Mason Lake and Outer Bay plutons.

Microcline phenocrysts in the Outer Bay pluton display grid twinning and contain minor, small inclusions of plagioclase and hornblende. Their granitic groundmass is medium- to coarse grained and characterized by subhedral-euhedral plagioclase weakly altered to saussurite, anhedral, interstitial quartz, and biotite and hornblende. Accessory phases include epidote, titanite, carbonate and opaque minerals.

Mafic Intrusive Rocks (Unit 11)

Early Proterozoic northwest-trending diabase dikes are a minor constituent of the map area. They range from <1 to 20 m wide, are aphanitic to medium grained and have a diabasic-textured, well defined chill margins. Epidote-hornblende hornfels contact aureoles have developed in country rocks adjacent to these dikes. The width of the aureoles is proportional to dike width; none is greater than 20 m wide.

These dikes have diabasic textures characterized by 50-60%, 0.25-1 mm plagioclase laths interstitial to 0.5-2 mm anhedral, equant clinopyroxene crystals. Late crystallizing, interstitial phases include hornblende (3-5%), quartz (2-3%), and opaque minerals (1-2%). Chlorite occurs as a minor alteration product of clinopyroxene.

These diabase dikes are part of the 2.1 Ga old Kenora-Kabetogama swarm (Southwick and Day, 1983; Halls, 1986; Southwick and Halls, 1987).

GEOCHEMISTRY

Introduction

Seventy four rock samples were analysed for major elements and selected trace elements; thirty-eight of these were subsequently analysed for rare earth elements (REE). Care was taken in the field to sample the freshest and most representative parts of each rock unit. Individual clasts were sampled from coarse pyroclastic deposits. Results are presented in Tables 3-9, and corresponding sample descriptions in Table 10 and sample locations on Figure 6.

All analyses were performed by the Geoscience Laboratories of the Ontario Geological Survey. Major elements were determined by X-Ray fluorescence on fused discs. Loss on ignition (LOI) was by gravimetric methods, CO_2 and S were by IR.

Be, Co, Cu, Mo, Ni, Sc, V and Zn were analysed by Inductively Coupled Plasma (ICP)/Optical Emission Spectrometry (OES). Nb, Rb, Sr, Th, Y, and Zr were analysed by XRF. The rare earth elements were analsed by ion-exchange (IE) chromotography/ICP/OES.

The following discussion of geochemical results is organized according to lithologies as mapped in the field.

Metavolcanic Rocks

Subvolcanic Metavolcanics

Ultramafic and mafic metavolcanics (Unit 1)

Four samples (212, 406, 1437, 1442) from ultramafic metavolcanics were analysed for major and selected trace elements. Two of these (406, 1437) were analysed for REE's (Table 3). Analyses of ultramafic metavolcanics are similar in having high MgO (11.6-11.9%), high Ni (300-315 ppm), high Cr (880-920 ppm), low TiO2 (.6%), low K_2O (<.1%) and low P_2O_5 (<.05%) (Table 3, Fig. 7). In these respects ultramafic flows in the Monument Bay resemble those in the Northwest Angle Inlet area (Morrice, 1988). These analyses plot in the basaltic komatiite field on a cation plot (Jensen, 1976) (Fig.7) and in the tholeiitic field on an AFM plot (Irvine and Baragar 1971) (Fig. 9). On a chondrite-normalized REE diagram, these basaltic komatiites have flat to slightly light-depleted patterns at 6-9x chondrites with $(Ce/Yb)_N$=0.7-0.9 (Fig.9).

Nine samples (235, 405, 584a, 1173, 1262, 1436, 1438, 1439, 1443) from mafic metavolcanics were analysed. These samples are characterised by low K_2O (.1-.6%), and variable MgO (2.8-7.0%) and Cr (44-366 ppm) contents (Table 3, Fig.6). Mafic metavolcanics plot in the tholeiitic fields on both the cation

(Jensen, 1976) and AFM diagrams (Irvine and Baragar, 1971) (Figs.8, 9).

REE were determined for four (235, 405, 1438, 1439) of the mafic metavolcanics. Chondrite-normalized REE patterns are flat ($(Ce/Yb)_N$=0.9-1.2) at 10-15x chondrites (Fig.10).

Alkalic to Calc-alkalic Metavolcanics

Mafic Metavolcanics (Unit 2)

Twenty-one samples from Unit 2 alkalic mafic metavolcanics (30, 38, 44, 45, 46, 51, 70, 164, 177, 187, 242, 309, 321, 325, 329, 397, 424, 451, 1047, 1058, 1431) were analysed for major and selected trace elements. Six of these (44, 46, 51, 177, 309, 1047) were analysed for REE Table 4). Analysed samples include clinopyroxene-phyric flows and tuffs, and plagioclase-phyric flows and clasts in tuff breccia units. These samples display a wide range in SiO_2 (47-60%), MgO (2.6-10.6%), K_2O (.2-4.0%), and Cr (14-695 ppm) (Table 4, Fig.6). Apparently both mafic and intermediate rocks are included in Unit 1. Several samples plot in the "shoshonitic assemblage" field of Fig.7.

Despite a wide range of K_2O contents, REE patterns are uniformly steeply inclined ($(Ce/Yb)_N$= 4-14) (Fig.10). The relatively immobile REE's are generally considered to be a better indicator of parental magma compositions than the more mobile alkali elements. The steep REE patterns are characteristic of alkalic volcanics (eg. Kay and Gast, 1973) indicating that samples with low K_2O contents are alkalic in nature and may have experienced some potassium depletion.

Intermediate Metavolcanics (Unit 3)

Eleven samples (42, 49, 86, 137, 167, 169, 191, 220, 293, 299, 300) from Unit 3 were analysed for major and trace elements. Seven of these (49, 137, 167, 191, 220, 299, 300) were analysed for REE (Table 5). These samples display a wide range of compositions as exemplified by SiO_2 (48-64%), CaO (4.2-11.4%), and K_2O (0.2-2.2%) (Table 5, Fig.6). These analyses include samples from plagioclase-phyric flows and clasts from heterolithic and monolithic tuff breccia units. Sample 300 is from an intensely amphibolitized flow.

REE patterns for all seven samples are similar. All are light-enriched with $(Ce/Yb)_N$= 5-21. There is a pronounced flattening of REE patterns at the heavy-REE end of the diagram (Fig.11). Samples 299 and 300, from the same outcrop, represent an unaltered and an intensely amphibolitized plagioclase-phyric pillowed flow, respectively. Note that this alteration is characterised by considerable mobility of major elements (addition of CaO, MgO, loss of K_2O, Na_2O) (Table 5). The REE, however, have been little affected as a result of this alteration, exhibiting only slight enrichment in the light REE's (Fig.11).

Intermediate-Felsic Metavolcanics (Unit 4)

Eighteen samples (26, 34, 35, 39, 53, 117, 161, 247, 316, 324, 328, 345, 346, 353, 354, 598, 602, 1057) of intermediate-felsic metavolcanics were analysed for major and selected trace elements. Four of these (53, 117, 161, 316) were analysed for REE (Table 6). These analyses are mainly of clasts from tuff breccia units.

SiO_2 ranges from 60 to 73%, MgO from 0.5-2.2% and K_2O from 0.2 to 2.9% (Table 6, Fig.6). REE patterns are steeply inclined with $(Ce/Yb)_N$= 5-24. Heavy REE's are especially low, at 1-7x chondrites (Fig.12).

Intrusive Rocks

Metamorphosed Mafic Intrusive Rocks (Unit 7)

Two samples of metamorphosed mafic intrusive rocks from synvolcanic sills were analysed (43, 185) (Table 7). Sample 185 is medium-grained equigranular, and Sample 43 is plagioclase-phyric, containing cm-long tabular plagioclase phenocrysts in a fine grained groundmass. Sample 185 is similar in major elements to the subalkalic mafic metavolcanics and probably is a subvolcanic sill related to these metavolcanics. This sample plots in the tholeiitic fields of both cation (Jensen, 1976) and AFM diagrams (Figs.8,9). Sample 43, however, contains greater K_2O content and may be related to the alkalic suite of metavolcanics (Fig.7).

Metamorphosed Intermediate-Felsic Intrusive Rocks (Unit 8)

Three samples of metamorphosed intermediate to felsic intrusive rocks were analysed for major and trace elements (116, 288, 440) (Table 8). All are similar geochemically, having greater than 64% SiO_2 and 2.6-3.5% K_2O (Fig.7). In many respects these metamorphosed intrusive rocks are geochemically similar to the intermediate to felsic metavolcanics into which they intrude, which is consistent with the interpretation that they are synvolcanic. However, the intrusive rocks have K_2O contents that are higher than most of the intermediate-felsic metavolcanics. This may indicate that the intrusive rocks belong to a high-K_2O suite, of which samples 34 and 117 are metavolcanic members. This high K_2O suite is distinct from intermediate-felsic metavolcanics which have lower K_2O contents (Fig.6).

Alkalic Mafic Intrusive Rocks (Unit 10)

Three samples (443, 1068, 1070) from a lamprophyric intrusion in the southeast part of Monument Bay were analysed for major and trace elements (Table 9). These samples show a wide range in Fe2O3 (8.3-17.9%), MgO (3.4-10.7%), K2O (0.2-2.9%), and P2O5 (0.2-0.9%) (Table 9, Fig.6). Cr contents are low (<10-77 ppm).

Discussion

The geochemistry of the Monument Bay area builds on several features which were recognized in the Northwest Angle Inlet area (Morrice, 1988). Of prime importance is the confirmation of two distinct suites of metavolcanics which can be readily identified in the field. The presence of cm-size clinopyroxene phenocrysts in mafic metavolcanics, which resemble those phenocrysts found in Cenozoic alkalic basalts (eg. Morrice and Gill, 1986), serve to distinguish the alkalic basalts from the aphyric subalkalic basalts. Geochemically, these clinopyroxene-phyric basalts are characterized by higher K_2O contents and light-enriched REE patterns. In many respects they resemble the shoshonitic rock association (Joplin, 1968). The subalkalic basalts are characterized by low K_2O contents and flat REE patterns.

At the felsic end of the K_2O-SiO_2 variation diagram, a wide spectrum of compositions are present (Fig.6). Whether these rocks are derived from alkalic or subalkalic parents is unclear and beyond the scope of this report.

Similar clinopyroxene-phyric basalts have been documented at several other locations within the western Wabigoon Subprovince, including Sunshine Lake (Blackburn, 1981, 1982; Teal, 1979), Gibi Lake (Trowell, 1986), Rainy River (Glen Johns, geologist, Ontario Geological Survey, personal communication, 1987), Chisholm Island (Ayer, et al, 1987), near Sandybeach Lake northeast of Dryden (Ben Berger, geologist, Ontario Geological Survey, personal communication, 1987) and within the Crowduck Group of metasediments, north of Shoal Lake (M. Morrice, personal observations, 1987). Chemically these clinopyroxene-phyric basalts are different from those of the present area. They appear not to be alkalic (J. Ayer and B. Berger, Geologists, Ontario Geological Survey, personal communication). Reports of similar metavolcanics elsewhere in Superior Province include Cooke and Moorehouse (1969), Shegelski (1980), Brooks, et al (1982) and Corkery and Cameron (1987).

STRUCTURE AND METAMORPHISM

Structure

Reliable facing indicators that include shapes of pillows and contact relationships in flows, graded bedding, cross bedding, scour and fill and bomb sags in pyroclastics are unevenly preserved in the map area. Well preserved southeast facing directions dominate the north half of the map area. Facing reversals in the central part of the map area define two synclines and an intervening anticline (Fig. 3). Both small scale and related larger scale folds are characterized by axial planar cleavage and steeply west plunging fold axes. Recrystallization has destroyed top indicators in the southeast part of the map area and repetition of stratigraphy by folding and/or faulting is suggested by the presence of similar wacke horizons.

Most supracrustal lithologies in the map area have a well developed foliation which trends east to northeast except where deflected around granitic plutons (back pocket). Two ages of foliation are recognized: a dominate early (F1) pervasive east to northeast-trending schistosity (foliation), and locally gneissocity, and a later, locally developed fracture and crenulation cleavage (F2). This later cleavage is best observed in the metasediments of the Royal Island formation where it trends at 120°-140° and dips steeply. F1 foliation is generally parallel or near-parallel to layering except at fold closures northeast of La Vérendrye Island.

Shallow (30¼-50¼) dips characterize F1 foliations in the Monument Bay area (south dipping) and the southwestern part of the map area (north dipping). The cause of the shallow dips in the Monument Bay area is unknown but may be the result of reorientation of original steeply dipping foliation related to the east trending Monument Bay Deformation Zone. The shallow, north-dipping foliations in the south part of the map area are consistent with the Sabaskong Batholith having a broad, shallow-dipping shoulder. This is in concert with the wide thermal contact metamorphic aureole present along the northern margin of the Sabaskong Batholith.

Mineral and stretching lineations are defined by the preferred orientation of prismatic hornblende crystals, elongate clinopyroxene and recrystallized and stretched plagioclase phenocrysts in mafic and intermediate metavolcanics and elongate clasts in pyroclastic metavolcanics. Lineations, so defined, generally plunge steeply south to southeast, down the dip of the F1 foliation throughout the map area.

The most prominent deformation zone in the map area is the 50-200 m wide east- to northeast-trending Monument Bay Deformation Zone (MBDZ) (Photo 12). The MBDZ continues west into the Northwest Angle Inlet map area and northeast into the Western Peninsula and Chisholm Island areas where it joins up with a splay from the Pipestone-Cameron Deformation Zone (Buck, 1986; Ayer et al, 1987). Lithologies within this fault zone are variably sheared and carbonatized or amphibolitized. Kinematic indicators are (steeply dipping S-C fabrics, subvertical extensional crenulation cleavage, Z-folds with moderate to steeply plunging axis, asymmetric rotation of phenocrysts, asymmetric rotation of boudins with steeply dipping axes and bending of lithologies along the MBDZ south and west of Monument Bay (Morrice and MacMaster, 1987). These indicate that this is predominately a zone of flattening (pure shear) with a minor (late?) subhorizontal, predominantly dextral, component of simple shear. This is consistent with a northwest directed maximum compressive stress.

Discrete shear zones, less than 1-2 metres wide, are defined by an increase in intensity of schistosity and carbonate alteration. They occur throughout the map area but are best developed within and adjacent to the MBDZ where the shear zones trend approximately east-west at an angle to the northeast-trending MBDZ. Many of these shear zones host quartz-carbonate-pyrite veins (Photo 13), several of which contain anomalous gold concentrations (see below).

Deformation of intermediate-felsic metavolcanics in the southeast part of the map area characterized by the development of 070° and 110° trending, steeply dipping conjugate shear fractures. These are bisected by the regional foliation indicating that the shear fractures and foliation developed under the same regional stress field. In local areas minor subhorizontal sinistral movement has occurred along the 070° fracture direction (Photo 14). With increased flattening, these shear fractures rotate, until near parallel, into an anastomosing network (Photo 15). Individual fractures up to 0.5 cm thick appear to have been accentuated by mylonitization and alteration. The fractures in thin section have been observed to be annealed but are finer-grained than the adjacent non deformed host.

Metamorphism

Amphibolite facies mineral assemblages characterise lithologies in most of the map area with the amphibolite-greenschist transition trending approximately NW-SE across the northern part of the map area (Fig.13). Blue-green hornblende is prevalent in mafic metavolcanics that have been metamorphosed to amphibolite grade. Within pelitic metasediments biotite is abundant and porphyroblastic, andalusite, garnet and muscovite are ubiquitous and porphyroblastic staurolite occurs locally. Andalusite occurs as 0.5-2 cm diameter seive-textured knots, garnet porphyroblasts are anhedral seive-textured clots that range in diameter from 0.2-1 cm, muscovite porphyroblasts are 1-5 mm across and staurolite is present as small (<0.5 cm long), euhedral porphyroblasts. Migmatitic pelitic metasediments in the southeastern part of the map area are characterized by the presence of up to 50%, <1-3 cm thick, layers of quartz-plagioclase leucosomes with intervening biotite-rich melanosome layers (Photo 16). Sillimanite occurs as tiny needles within a feldspar porphyry sill which intrudes intermediate-felsic pyroclastics in the northeast part of the map area. The presence of sillimanite may indicate assimilation of pelitic sediments by the feldspar porphyry. Greenschist mineral assemblages are characterized by actinolite, chlorite and carbonate in mafic metavolcanics.

Intense recrystallization of the supracrustals in the southern part of the map area and the extensive development of amphibolite grade metamorphic assemblages are related to thermal effects of the Sabaskong Batholith (Blackburn, 1981). A similarly wide thermal aureole has developed along the south flank of the Sabaskong Batholith (Glen Johns, geologist, Ontario Geological Survey, personal communication, 1987). These aureoles (10-15 km wide) and the shallow dips of supracrustal rocks along the north flank of the Batholith are consistent with the Sabaskong batholith having broad, shallow, outward dipping shoulders.

Epidote-hornblende hornfels contact aureoles have developed in country rocks adjacent to diabase dikes and the Mason Lake and Outer Bay granodiorite plutons. These aureoles are less than 1 km wide around the granitoid plutons and less than 50 m wide adjacent to diabase dikes. Up to 35% euhedral-subhedral epidote is closely associated with hornblende in these aureoles. Minor local retrograde metamorphism has developed in amphibolite facies rocks adjacent to quartz veins and pegmatite dikes and along the MBDZ.

ECONOMIC GEOLOGY

Introduction

Recorded information concerning mineral exploration in the Monument Bay map area is limited to accounts of base metal exploration in the 1970's by Hudson Bay Exploration and Development Company Limited and Phelps Dodge Corporation of Canada Limited (Assessment files, Resident Geologist's Office, Ontario Ministry of Northern Development and Mines, Kenora).

During the 1987 field program, 242 samples from mineralized and altered zones throughout the map area were collected for geochemical analyses. These analyses are presented in Table 11; sample locations are plotted on Figure 15. A number of these samples contain anomalous amounts of gold (Table 12).

At the commencement of the 1987 field season, there were no claims in good standing in the map area.

Description of Properties

The following information has been obtained from the assessment files of the Resident Geologist's Office, Ontario Ministry of Northern Development and Mines, Kenora.

Hudson Bay Exploration and Development (1)

Base-metal (zinc, copper) exploration was carried out by Hudson Bay Exploration and Development Company Limited (HBED) in the western part of the map area (back pocket). In 1975 HBED diamond drilled three holes to test ground electromagnetic anomalies. A 93.6 m long hole in the south part of Monument Bay encountered intermediate-felsic metavolcanics with numerous thin (<1 m) sulphide (pyrite, pyrrhotite, graphite) intersections. Two holes (96 m, 115.1 m) drilled on Cochrane Island intersected mafic and intermediate metavolcanics and minor porphyry dikes. Sulphide intersections were numerous but thin (<1 m: tr-8% pyrrhotite, tr-2% pyrite). No assay results were submitted with the logs from these drill holes.

Phelps Dodge Corporation of Canada Limited (2)

Phelps Dodge Corporation (PDC) drilled one 93.3 m long diamond drill hole in the northern part of the map area (back pocket). This hole intersected mainly mafic metavolcanics with significant sulphides encountered from 41.3-46.3 m (10% pyrite, 25% pyrrhotite, minor graphite) and from 74.8-77.1 m (5% pyrite, 20% pyrhottite in graphite schist). A trace of chalcopyrite (with 10% pyrite) was present at 26.7 m. No assay results were submitted with the log from this drill hole.

Alteration

Two alteration mineral assemblages are widespread in the Monument Bay area: chlorite ± carbonate alteration in greenschist facies rocks, and hornblende ± garnet ± carbonate alteration within amphibolite facies metavolcanics (Fig.14). These two alterations appear to have formed from hydrothermal fluids of similar composition; their contrasting mineralogy is the result of either formation under different P,T conditions (ie. at peak or post peak metamorphic conditions) (cf. Andrews et al., 1986) or the elevation of a portion of a low grade alteration assemblage to a higher metamorphic grade assemblage (ie. alteration under pre-peak metamorphic conditions). Replacement textures of hornblende after metamorphic biotite and hornblende overgrowths on hornblende pseudomorphed clinopyroxene phenocrysts indicate that alteration occurred under peak to post-peak metamorphic conditions. The style of alteration is similar for both amphibolitization and carbonatization and was controlled largely by preexisting permeability in the host rock. This includes primary features such as rubbly flow tops and the fine grained clastic matrix of coarse pyroclastics and secondary features such as fractures. Alteration may be present as thin fracture fillings or veins up to 25 cm wide, may selectively alter matrix material (Photo 17) or may wholly alter a particular rock unit or series of units. The degree of alteration is highly variable within these zones, ranging from rocks which are essentially nonaltered to rocks which have been wholly replaced by alteration mineral assemblages.

Amphibole ± garnet alteration has affected most lithologic units in the map area and is well developed in a 2.5 km wide northeast trending swath which transects the central part of the map area (Fig.13). The amphibole is black acicular, hornblende commonly occurring as 0.1-1 cm long needles randomly oriented in the plane of foliation. Garnet occurs as red (andradite ?) anhedral to euhedral, 1-8 mm diameter, porphyroblasts. Compositional variability of this alteration is indicated by the variable abundance of garnet; assemblages with high modal garnet (up to 30 %) are presumably more iron-rich than those assemblages which lack or contain minor garnet. This implies that the altering fluids contained variable iron contents seen in thin section, incipient hornblende alteration of clinopyroxene-phyric mafic metavolcanics is preserved as blue-green hornblende overgrowths on paler green hornblende pseudomorphs (after clinopyroxene phenocrysts). Groundmass alteration is characterized by the presence of prismatic hornblende.

Plagioclase-phyric intermediate metavolcanics have been variably altered in the Johnston Passage area. Here, incipient alteration occurs as minor replacement of plagioclase phenocrysts by hornblende (Photo 18). With advanced alteration, the primary porphyritic texture is destroyed resulting in an aphyric, fine-grained, mafic looking rock with approximately 50-60% prismatic hornblende and 35-40% fine-grained, granoblastic plagioclase and quartz. Geochemically, hornblende alteration is characterized by the addition of CaO, MgO and minor Fe_2O_3 and depletion of Al_2O_3, Na_2O and K_2O (Table 5). However, the REE's remain relatively inert through this alteration and retain pristine patterns, characteristic of alkalic volcanics (Fig.11).

Carbonate alteration is most intense northeast of Cochrane Island within the high strain zone which has affected both alkalic and subalkalic mafic metavolcanics. As with the amphibole alteration, carbonate alteration can occur in discrete veins or selectively or wholly replace the host lithology (Photo 19). This alteration also occurs near the high strain zone to the southwest on the amphibolite side of the metamorphic isograd, indicating either retrograde metamorphism or late alteration in this area. The dominate carbonate weathers tan-brown (ferroan dolomite ?).

Discussion of Assay Results

35 samples from 24 separate locations contain greater than 100 ppb gold (Table 12, Fig.15). This is the first indication that anomalous abundances of gold occur in this part of Lake of the Woods. Most of these anomalous values occur associated with quartz-carbonate-pyrite veins in approximately E-W trending, steeply dipping, shear zones. These shear zones have developed in mafic metavolcanic rocks of Units 1 and 2 (back pocket) (Photo 13). Individual variably carbonatized shear zones are less than 2 metres wide. However, the highest gold values (up to 52.3 ppm Au; location 23, back pocket) are not associated with a discrete

shear zone but with thin (<0.5 cm wide) quartz-carbonate-chalcopyrite veinlets in fractured and locally sheared mafic metavolcanics.

Anomalous gold contents are associated with anomalous arsenic values or anomalous base metal values (Table 12).

Guidelines for Mineral Exploration

Base Metals (Zn, Cu)

Base-metal (zinc, copper) exploration should focus on felsic metavolcanics west of Outer Bay. Here mono- to heterolithic quartz-plagioclase-phyric pyroclastics contain local cm-size sulfide (pyrrhotite, pyrite) clasts. The change from mono- to heterolithic proclastics may be related to reworking of the brecciated carapace of a felsic dome. The sulfide clasts may be reworked exhalative sulphides. This is a classic geological environment for base metal deposition (eg. Franklin et al, 1981).

Gold

Gold exploration should be directed primarily to two areas: the shear zones within mafic metavolcanics of the Cochrane Island and Separation Point formations, and the region of extensive hornblende ± garnet alteration further south (Fig.13). The amphibolite-greenschist facies boundary crosses both trends at near right angles and should direct initial exploration. A number of samples collected from shear zones in the mafic metavolcanics by members of the field party contain >100 ppb gold (Table 12). These anomalous results are, in part, stratigraphically controlled, occurring intermittently along >10 km of strike length of the subalkalic mafic metavolcanics of the Cochrane Island formation. The highest gold values (up to 52.3 ppm Au) are associated with quartz-carbonate-chalcopyrite veinlets in fractured and sheared mafic metavolcanics northeast of Cochrane Island. Favourable host lithology (mafic metvolcanics), structure (shear zones), alteration (carbonatization), and metamorphic conditions (at or near the amphibolite-greenschist facies transition) have provided a very attractive area in which to explore for precious metals (eg. Groves et al, 1985).

Sulphides occur in discrete zones within altered (hornblende ± garnet) intermediate to felsic metavolcanics west of Johnston Passage. Samples collected from these sulfide zones contain only background values of gold. However, this alteration zone should be explored, especially to the northeast, on the greenschist side of the amphibolite-greenschist isograd, where conditions may be more favourable for gold deposition (eg. Groves et al, 1985).

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TABLE 1 TABLE OF LITHOLOGIC UNITS FOR THE MONUMENT BAY AREA.

PHANEROZOIC
  CENOZOIC
    Quaternary
      Pleistocene and Recent
        Glacial, glacial-fluvial, swamp, lake and stream deposits

Unconformity

PRECAMBRIAN
  PROTEROZOIC
    Mafic Intrusive Rocks
      Diabase, quartz diabase

Intrusive Contact

  ARCHEAN
    Intermediate to Felsic Intrusive Rocks
      Aplite, pegmatite, biotite-hornblende granite, hornblende-biotite granodiorite, hornblende diorite,

Intrusive Contact

    Alkalic Intrusive Rocks
      Syenite, lamprophyre, biotite lamprophyre, hornblendite, monzodiorite, pebble dyke

Intrusive Contact

    Metamorphosed Intermediate to Felsic Intrusive Rocks
      Quartz-feldspar porphyry, feldspar porphyry, felsite.

Intrusive Contact

    Metamorphosed Mafic Intrusive Rocks
      Gabbro, melagabbro, leucogabbro, quartz gabbro, fine grained gabbro, mafic feldspar porphyry.

Intrusive Contact

    Metamorphosed Ultramafic Intrusive Rocks
      Pyroxenite, hornblendite.

Intrusive Contact

- Metavolcanic and Metasedimentary Rocks
  - Clastic and Chemical Metasedimentary Rocks
    - Feldspathic wacke, quartz-feldspar wacke, siltstone, arenite, argillite, conglomerate chert, ironstone, quartz-plagioclase-biotite schist
  - Intermediate to Felsic Metavolcanic Rocks (Alkalic-Calcalkalic)
    - Tuff, lapilli tuff, lapillistone, tuff breccia, massive flow, pillowed flow, flow breccia
  - Intermediate Metavolcanic Rocks (Alkalic-Calcalkalic)
    - Massive flow, pillowed flow, flow breccia, tuff, lapilli tuff, lapillistone, tuff breccia,
  - Mafic Metavolcanic Rocks (Alkalic-Calcalkalic)
    - Clinopyroxene-phyric massive flows, pillowed flows, pillow breccia, tuff, lapilli tuff, lapillistone, tuff breccias.
  - Ultramafic to Mafic Metavolcanic Rocks (Subalkalic)
    - Fine-grained massive flows, coarse-grained massive flows (may in part be intrusive), pillowed flows, pillow breccia, tuff, lapilli tuff, tuff breccia.

Table 2. Table of Formations for the Monument Bay Area.

Johnston Passage formation (0-500 m)[1]
-intermediate pillowed flows, pillow breccia
-plagioclase-phyric, vesicular

Long Island formation (450 m)
-thick-bedded wacke, minor iron formation

Drift Island formation (1500 m)
-intermediate-felsic pyroclastics
-plagioclase-phyric

Betty Island formation (400 m)
-wacke, iron formation

East Windigo Island formation (600 m)
-mafic pyroclastics
-clinopyroxene-phyric

Burnt Island formation (200 m)
-wacke

Clipper Island formation (500-1000 m)
-mafic pillowed flows; mafic, intermediate pyroclastics
-clinopyroxene-, plagioclase-phyric

Royal Island formation (200 m)
-thick bedded wacke

La Verendrye Island formation (0-2000 m)
-intermediate-felsic pyroclastics
-aphyric

South Bay formation (0-1900 m)
-mafic, intermediate pyroclastics, mafic flows
-clinopyroxene-, plagioclase-phyric

Separation Point formation (0-1700 m)
-mafic pyroclastics, flows
-clinopyroxene-, plagioclase-phyric, vesicular

Cochrane Island formation (600-2000 m)
-ultramafic, mafic pillowed and massive flows
-aphyric, non-vesicular, variolitic

Monument Bay formation (600-2500 m)
-mafic pyroclastics, massive and pillowed flows; intermediate-felsic pyroclastics
-clinopyroxene-phyric, vesicular

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[1] Approximate thickness of formation, in metres.

Mason Lake formation (1500-2000 m)
- intermediate-felsic pyroclastics
    - plagioclase-, quartz-phyric

Partridge Lake formation (>500 m)
- mafic flows, pyroclastics
    - plagioclase-phyric

Table 3: Geochemistry of Mafic to Ultramafic Metavolcanics (Unit 1)

Whole Rock Analyses
MAJOR OXIDE LISTING

	87MGM-0212	87MGM-1442	87MGM-1439	87MGM-0405	87MGM-584A	87MGM-1438
SiO2	46.80	48.00	51.40	51.20	51.60	51.70
Al2O3	13.20	13.50	13.70	14.10	13.50	14.60
Fe2O3	12.00	11.80	10.40	12.50	11.50	11.90
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	11.90	11.60	8.84	7.61	7.04	6.75
CaO	9.69	9.22	10.90	11.10	11.30	10.30
Na2O	1.34	0.96	1.36	1.16	1.82	1.63
K2O	0.03	0.05	0.17	0.14	0.20	0.13
TiO2	0.56	0.58	0.57	0.71	0.67	1.08
P2O5	0.04	0.04	0.03	0.06	0.05	0.10
MnO	0.18	0.17	0.18	0.21	0.22	0.17
CO2	0.14	0.15	0.91	0.08	0.78	0.10
S	0.07	0.05	0.01	0.05	0.06	0.06
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	3.30	4.10	2.00	0.60	1.00	0.70
TOTAL	99.00	100.00	99.50	99.40	98.90	99.10
S.G.	3.04	2.99	3.00	3.05	3.01	3.03

TRACE ELEMENTS

	87MGM-0212	87MGM-1442	87MGM-1439	87MGM-0405	87MGM-584A	87MGM-1438
Co	61	60	45	46	44	42
Cr	880	920	455	300	366	264
Cu	81	110	12	109	110	79
Ni	300	315	96	74	78	62
Pb	-10	-10	-10	-10	-10	-10
Zn	85	90	97	115	94	97
Be	-1	-1	1	1	-1	1
Co	62		46	55		42
Cu	82		15	123		87
Mo	-10	-10	-10	11	-10	-10
Ni	306		106	92		69
Sc	36	36	49	54	46	48
Sr	108	101	104	115	82	119
V	225	220	263	299	288	320
Y	17	15	16	22	19	29
Zn	70		97	117		94
Nb	-5	-5	-5	-5	-5	-5
Rb	-5	-5	-5	-5	-5	-5
Sr	115	107	110	127	88	131
Y	21	17	15	19	19	34
Zr	66	64	62	73	70	110
Th	-10	11	-10	-10	-10	-10
Pr			820 B	1.10		1.80
Sm			1.30	1.70		3.20
Eu			560 B	590 B		1.10
Gd			1.90	2.30		4
Tb			320 B	440 B		720 B
Dy			2.20	2.80		4.90
Ho			520 B	640 B		1
Er			1.40	1.90		3
Tm			240 B	280 B		460 B
Yb			1.60	1.80		3
Lu			270 B	250 B		440 B
Ce			6.60	8		14
La			3.20	3.10		5.10
Nd			4	5.60		10
Y			12	16		28

MAJOR OXIDE LISTING

	87MGM-0406	87MGM-1437	87MGM-1443	87MGM-1262	87MGM-1173	87MGM-0235
SiO2	51.50	51.50	46.20	53.10	52.80	50.40
Al2O3	14.80	15.20	14.80	14.70	15.80	16.60
Fe2O3	12.60	11.70	9.99	14.40	10.00	13.30
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	6.18	5.68	5.66	3.80	3.63	3.08
CaO	10.10	10.80	15.30	7.15	6.28	10.60
Na2O	1.90	1.91	1.85	4.39	3.20	2.45
K2O	0.15	0.19	0.13	0.60	1.36	0.49
TiO2	0.79	0.96	0.54	1.04	0.72	1.17
P2O5	0.07	0.07	0.07	0.14	0.16	0.14
MnO	0.19	0.26	0.18	0.27	0.18	0.19
CO2	0.09	0.31	3.08	0.29	3.38	0.31
S	0.03	0.01	0.24	0.09	0.03	0.02
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	0.50	0.70	3.50	0.30	5.30	0.50
TOTAL	98.80	99.00	98.20	99.90	99.40	98.90
S.G.	3.04	3.01	3.04	2.98	2.78	3.00

TRACE ELEMENTS

	87MGM-0406	87MGM-1437	87MGM-1443	87MGM-1262	87MGM-1173	87MGM-0235
Co	45	45	44	36	33	37
Cr	82	322	354	44	41	38
Cu	117	25	93	100	54	156
Ni	54	130	98	14	39	29
Pb	-10	-10	-10	-10	-10	17
Zn	100	99	77	132	91	120
Be	1	1	-1	-1	1	2
Co	45	49			35	35
Cu	124	27			62	169
Mo	-10	-10	-10	-10	-10	-10
Ni	62	137			47	32
Sc	42	43	33	38	25	34
Sr	117	118	285	197	420	235
V	282	279	241	343	190	305
Y	18	26	12	29	20	26
Zn	100	100			94	114
Nb	-5	-5	-5	-5	-5	-5
Rb	-5	-5	-5	15	38	-5
Sr	132	127	305	214	403	242
Y	22	30	14	34	21	32
Zr	79	103	79	128	139	116
Th	-10	-10	-10	-10	-10	-10
Pr	1.10	1.80			5.20	2.90
Sm	1.80	2.80			4.10	3.50
Eu	690 B	1.10			1.20	1.10
Gd	2.50	3.90			3.70	4
Tb	430 B	690 B			580 B	700 B
Dy	3	4.20			3.50	4.50
Ho	730 B	980 B			740 B	1
Er	2	2.80			2.30	3
Tm	310 B	450 B			350 B	450 B
Yb	1.90	2.70			2.20	2.90
Lu	310 B	460 B			380 B	420 B
Ce	8.10	13			46	20
La	3.10	5			19	8.40
Nd	5.70	8.80			23	13
Y	16	24			20	27

MAJOR OXIDE LISTING

	87MGM-1436
SiO2	49.80
Al2O3	16.80
Fe2O3	13.00
FeO	00.00
MgO	2.84
CaO	10.80
Na2O	2.89
K2O	0.50
TiO2	1.16
P2O5	0.19
MnO	0.25
CO2	0.24
S	0.12
H2O+	00.00
H2O-	00.00
LOI	0.50
TOTAL	98.70
S.G.	3.08

TRACE ELEMENT LISTING

	87MGM-1436
Co	49
Cr	196
Cu	47
Ni	70
Pb	-10
Zn	137
Be	-1
Mo	-10
Sc	36
Sr	362
V	267
Y	24
Nb	-5
Rb	-5
Sr	366
Y	29
Zr	119
Th	-10

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES: 13

	MEAN	STD. DEVIATION
SiO2	50.46	2.18
Al2O3	14.72	1.15
Fe2O3	11.93	1.29
FeO	0.00	0.00
MgO	6.51	2.95
CaO	10.27	2.15
Na2O	2.07	0.95
K2O	0.32	0.36
TiO2	0.81	0.24
P2O5	0.09	0.05
MnO	0.20	0.04
CO2	0.76	1.13
S	0.06	0.06
H2O+	0.00	0.00
H2O-	0.00	0.00
LOI	1.77	1.70
TOTAL	99.14	0.50
S.G.	3.00	0.07

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Co	13	45.15	8.15
Cr	13	327.85	289.17
Cu	13	84.08	40.37
Ni	13	104.54	95.16
Pb	13	-7.92	7.49
Zn	13	102.62	18.07
Be	13	0.15	1.14
Co	8	46.12	9.30
Cu	8	86.12	51.85
Mo	13	-8.38	5.82
Ni	8	106.37	87.36
Sc	13	40.00	7.92
Sr	13	181.77	110.90
V	13	270.92	43.07
Y	13	21.00	5.48
Zn	8	98.25	14.35
Nb	13	-5.00	0.00
Rb	13	-0.15	12.73
Sr	13	189.77	106.83
Y	13	23.62	7.22
Zr	13	92.92	27.06
Th	13	-8.38	5.82
Pr	7	119.13	309.06
Sm	7	2.63	1.05
Eu	7	263.50	329.59
Gd	7	3.19	0.91
Tb	7	554.29	158.73
Dy	7	3.59	0.99
Ho	7	516.00	377.96
Er	7	2.34	0.62
Tm	7	362.86	90.87
Yb	7	2.30	0.57
Lu	7	361.43	84.74
Ce	7	16.53	13.80
La	7	6.70	5.74
Nd	7	10.01	6.50
Y	7	20.43	6.11

Table 4: Geochemistry of Alkalic Mafic Metavolcanics (Unit 2)

Whole Rock Analyses

MAJOR OXIDE LISTING

	87MGM-0038	87MGM-1431	87MGM-1058	87MGM-0164	87MGM-0046	87MGM-0242
SiO2	47.20	50.20	50.80	54.30	50.70	47.60
Al2O3	11.60	13.10	13.90	14.40	17.10	14.50
Fe2O3	10.20	11.10	9.51	9.81	8.90	11.30
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	10.60	8.34	7.11	6.46	6.04	5.90
CaO	12.70	10.20	8.54	8.69	10.90	8.84
Na2O	1.35	1.95	1.96	2.43	2.76	2.11
K2O	0.48	1.90	2.83	0.92	0.20	3.99
TiO2	0.60	0.95	0.65	0.67	0.67	0.83
P2O5	0.20	0.41	0.16	0.21	0.20	0.45
MnO	0.14	0.19	0.15	0.16	0.19	0.19
CO2	1.70	0.31	2.37	0.28	0.86	2.23
S	0.02	0.01	0.01	0.05	0.01	0.01
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	2.40	1.40	3.10	0.70	1.20	2.80
TOTAL	97.50	99.70	98.70	98.80	98.90	98.50
S.G.	3.05	2.99	2.91	2.93	2.92	2.92

TRACE ELEMENT LISTING

	87MGM-0038	87MGM-1431	87MGM-1058	87MGM-0164	87MGM-0046	87MGM-0242
Co	44	39	35	41	36	35
Cr	695	178	270	278	143	156
Cu	89	20	87	65	87	131
Ni	235	63	53	108	86	38
Pb	-10	-10	-10	-10	-10	-10
Zn	82	110	85	83	91	117
Be	-1	2	-1	-1	-1	-1
Co	39	41	37	43	34	36
Cu	85	23	88	65	84	133
Mo	-10	-10	-10	-10	-10	-10
Ni	196	75	59	122	84	45
Sc	36	36	31	27	34	24
Sr	422	592	677	413	426	935
V	247	250	213	191	246	227
Y	14	24	15	15	15	21
Zn	59	110	76	77	71	102
Nb	-5	-5	-5	-5	-5	-5
Rb	8	51	74	30	-5	111
Sr	422	582	669	416	415	968
Y	17	23	15	17	18	21
Zr	117	145	140	134	120	175
Th	-10	12	-10	-10	-10	16
Pr		10			4.10	
Sm		8.50			3.20	
Eu		2.30			1	
Gd		6.30			2.90	
Tb		880 B			440 B	
Dy		4.40			2.80	
Ho		820 B			600 B	
Er		2.30			1.70	
Tm		320 B			250 B	
Yb		2.10			1.70	
Lu		300 B			250 B	
Ce		83			30	
La		38			13	
Nd		42			15	
Y		22			16	

MAJOR OXIDE LISTING

	87MGM-0424	87MGM-0177	87MGM-0309	87MGM-0397	87MGM-1047	87MGM-0045
SiO2	53.70	55.70	54.00	53.20	53.90	49.00
Al2O3	14.00	16.40	16.40	13.10	13.70	17.30
Fe2O3	8.46	9.04	8.60	8.08	8.52	10.60
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	5.40	5.31	5.12	5.12	4.53	4.15
CaO	6.67	7.67	9.88	9.40	9.50	9.94
Na2O	3.66	2.83	2.51	2.77	2.42	3.47
K2O	3.59	0.36	0.32	2.55	1.71	0.87
TiO2	0.72	0.64	0.88	0.58	0.60	0.88
P2O5	0.41	0.14	0.49	0.27	0.18	0.42
MnO	0.14	0.14	0.19	0.12	0.16	0.15
CO2	1.10	0.09	0.37	3.42	3.87	2.00
S	0.01	0.01	0.01	0.02	0.01	0.01
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	1.80	1.00	0.80	4.80	4.50	2.20
TOTAL	98.60	99.20	99.20	99.90	99.70	99.00
S.G.	2.88	2.88	2.91	2.89	2.84	2.88

TRACE ELEMENT LISTING

	87MGM-0424	87MGM-0177	87MGM-0309	87MGM-0397	87MGM-1047	87MGM-0045
Co	33	31	37	31	31	33
Cr	174	111	195	316	222	174
Cu	44	16	59	75	86	32
Ni	41	60	51	73	55	85
Pb	10	-10	-10	-10	-10	-10
Zn	103	71	100	85	72	104
Be	-1	-1	-1	-1	-1	-1
Co		32	43		29	30
Cu		11	64		82	28
Mo	-10	-10	-10	-10	-10	-10
Ni		70	61		60	87
Sc	24	14	21	26	22	23
Sr	725	273	662	682	495	572
V	193	154	218	186	167	246
Y	20	13	19	18	12	16
Zn		56	87		58	84
Nb	-5	-5	-5	-5	-5	-5
Rb	102	7	8	59	55	27
Sr	690	304	672	637	521	570
Y	20	18	25	16	14	21
Zr	183	118	178	154	129	163
Th	15	-10	-10	10	-10	-10
Pr		2.90	13		3.30	
Sm		2.50	8.60		2.70	
Eu		770 B	2.20		730 B	
Gd		2.40	5.70		2.40	
Tb		350 B	700 B		320 B	
Dy		2.30	3.80		2	
Ho		490 B	730 B		420 B	
Er		1.40	1.90		1.20	
Tm		200 B	260 B		170 B	
Yb		1.30	1.60		1.10	
Lu		200 B	230 B		170 B	
Ce		22	92		25	
La		10	36		12	
Nd		12	50		12	
Y		13	21		12	

MAJOR OXIDE LISTING

	87MGM-0051	87MGM-0451	87MGM-0070	87MGM-0325	87MGM-0187	87MGM-0247
SiO2	60.00	55.10	50.40	52.80	56.30	55.30
Al2O3	13.80	13.70	16.10	14.70	14.20	16.40
Fe2O3	6.17	11.10	11.10	12.40	7.62	9.01
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	4.07	4.44	4.05	3.98	3.64	3.37
CaO	5.16	8.34	11.00	8.83	7.26	6.24
Na2O	3.64	3.71	3.08	3.83	2.62	2.86
K2O	2.20	0.25	0.21	1.38	2.63	1.31
TiO2	0.54	1.49	1.36	0.97	0.56	0.76
P2O5	0.14	0.15	0.11	0.36	0.13	0.14
MnO	0.12	0.15	0.16	0.19	0.13	0.16
CO2	2.59	0.10	1.70	0.16	2.91	2.34
S	0.01	0.01	0.01	0.06	0.01	0.01
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	2.90	0.60	1.70	0.50	3.20	4.20
TOTAL	98.70	99.00	99.30	99.90	98.30	99.70
S.G.	2.81	2.98	2.97	2.93	2.84	2.76

TRACE ELEMENT LISTING

	87MGM-0051	87MGM-0451	87MGM-0070	87MGM-0325	87MGM-0187	87MGM-0247
Co	21	37	29	37	27	31
Cr	118	185	186	167	107	36
Cu	31	26	7	62	55	36
Ni	34	91	46	98	54	40
Pb	-10	14	-10	-10	-10	18
Zn	65	148	98	129	84	85
Be	-1	2	-1	2	-1	1
Co	18	36	27	37	28	32
Cu	28	28	-1	69	54	43
Mo	-10	-10	-10	-10	-10	-10
Ni	39	93	50	103	62	46
Sc	18	22	22	23	18	24
Sr	487	390	311	1146	550	575
V	136	150	191	209	136	181
Y	10	19	15	21	12	21
Zn	50	149	83	128	77	85
Nb	-5	-5	-5	-5	-5	-5
Rb	60	-5	-5	19	73	41
Sr	454	396	314	1145	528	536
Y	13	21	21	21	12	21
Zr	137	146	124	142	143	143
Th	-10	-10	-10	-10	-10	-10
Pr	4.60	4.20		15		5.50
Sm	3.20	4.80		8.90		4.30
Eu	900 B	1.50		2.40		1.10
Gd	2.40	4.60		5.90		3.70
Tb	330 B	660 B		720 B		560 B
Dy	2	3.50		3.90		3.60
Ho	400 B	670 B		750 B		750 B
Er	1.10	1.70		2		2.20
Tm	160 B	210 B		290 B		310 B
Yb	1	1.40		1.80		1.90
Lu	140 B	200 B		250 B		280 B
Ce	37	34		130		47
La	17	13		54		20
Nd	16	21		61		23
Y	11	19		21		21

MAJOR OXIDE LISTING

	87MGM-0044	87MGM-0321	87MGM-0329	87MGM-0030
SiO2	51.50	51.20	54.00	57.80
Al2O3	16.00	15.60	16.40	14.80
Fe2O3	9.78	10.40	7.37	9.55
FeO	00.00	00.00	00.00	00.00
MgO	3.21	3.11	2.66	2.58
CaO	9.63	9.23	10.30	5.38
Na2O	3.91	2.60	4.08	3.26
K2O	0.60	1.41	0.22	2.58
TiO2	0.93	0.75	0.71	1.10
P2O5	0.43	0.29	0.22	0.69
MnO	0.15	0.21	0.36	0.15
CO2	2.55	3.44	2.78	0.32
S	0.01	0.01	0.02	0.06
H2O+	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00
LOI	2.70	3.70	3.10	1.00
TOTAL	98.80	98.50	99.40	98.90
S.G.	2.86	2.85	2.85	2.85

TRACE ELEMENT LISTING

	87MGM-0044	87MGM-0321	87MGM-0329	87MGM-0030
Co	28	35	50	22
Cr	197	54	59	14
Cu	30	49	61	49
Ni	84	53	77	8
Pb	-10	-10	-10	-10
Zn	97	96	75	132
Be	-1	-1	-1	-1
Co	26	34		
Cu	26	47		
Mo	-10	-10	-10	-10
Ni	88	57		
Sc	24	18	31	16
Sr	587	179	685	533
V	242	164	226	148
Y	17	17	19	35
Zn	76	85		
Nb	-5	-5	-5	9
Rb	12	47	-5	52
Sr	575	198	692	556
Y	23	21	22	45
Zr	164	130	134	276
Th	-10	-10	-10	13
Pr	10			
Sm	6.80			
Eu	1.70			
Gd	4.90			
Tb	640 B			
Dy	3.50			
Ho	710 B			
Er	1.90			
Tm	290 B			
Yb	1.80			
Lu	280 B			
Ce	76			
La	33			
Nd	38			
Y	19			

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Co	22	33.77	6.63
Cr	22	183.41	137.74
Cu	22	54.41	29.85
Ni	22	69.68	44.01
Pb	22	-6.73	8.52
Zn	22	96.00	21.11
Be	22	-0.50	1.10
Co	18	33.44	6.46
Cu	18	53.17	33.69
Mo	22	-10.00	0.00
Ni	18	77.61	36.85
Sc	22	24.27	6.14
Sr	22	559.86	213.30
V	22	196.41	38.46
Y	22	17.64	5.23
Zn	18	84.06	25.22
Nb	22	-4.36	2.98
Rb	22	37.09	34.49
Sr	22	557.27	210.80
Y	22	20.23	6.52
Zr	22	149.77	33.99
Th	22	-4.73	10.01
Pr	10	7.26	4.37
Sm	10	5.35	2.60
Eu	10	241.22	387.86
Gd	10	4.12	1.56
Tb	10	560.00	192.35
Dy	10	3.18	0.85
Ho	10	634.00	149.16
Er	10	1.74	0.40
Tm	10	246.00	57.97
Yb	10	1.57	0.36
Lu	10	230.00	51.85
Ce	10	57.60	35.89
La	10	24.60	14.77
Nd	10	29.00	17.51
Y	10	17.50	4.17

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES: 22

	MEAN	STD. DEVIATION
SiO2	52.94	3.19
Al2O3	14.87	1.50
Fe2O3	9.48	1.49
FeO	0.00	0.00
MgO	4.96	1.93
CaO	8.83	1.86
Na2O	2.90	0.73
K2O	1.48	1.16
TiO2	0.81	0.25
P2O5	0.28	0.15
MnO	0.17	0.05
CO2	1.70	1.24
S	0.02	0.02
H2O+	0.00	0.00
H2O-	0.00	0.00
LOI	2.29	1.32
TOTAL	99.01	0.58
S.G.	2.90	0.07

Table 5: Geochemistry of Intermediate Metavolcanics (Unit 3)

Whole Rock Analyses
MAJOR OXIDE LISTING

	87MGM-0300	87MGM-1358	87MGM-1306	87MGM-0042	87MGM-0220	87MGM-0049
SiO2	48.40	52.30	52.30	59.40	53.60	57.50
Al2O3	15.30	15.30	16.70	15.00	17.30	15.10
Fe2O3	11.70	8.63	9.81	6.89	9.42	9.33
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	5.53	4.30	4.28	4.10	3.51	3.10
CaO	11.40	7.27	7.30	6.43	8.76	4.45
Na2O	2.89	3.09	3.09	4.78	4.46	3.70
K2O	0.37	3.12	0.35	0.87	0.21	2.24
TiO2	0.85	1.17	0.67	0.49	0.98	1.05
P2O5	0.34	0.37	0.16	0.10	0.51	0.66
MnO	0.22	0.12	0.14	0.10	0.15	0.16
CO2	0.97	3.11	2.40	0.73	0.22	0.61
S	0.02	0.01	0.01	0.01	0.01	0.05
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	1.30	3.90	5.10	0.70	0.70	0.90
TOTAL	98.30	99.60	99.90	98.90	99.60	98.20
S.G.	3.04	2.83	2.88	2.65	2.92	2.81

TRACE ELEMENT LISTING

	87MGM-0300	87MGM-1358	87MGM-1306	87MGM-0042	87MGM-0220	87MGM-0049
Co	34	52	34	24	28	17
Cr	118	191	53	134	56	-10
Cu	28	21	76	53	61	37
Ni	88	161	50	56	63	-5
Pb	-10	-10	-10	-10	-10	-10
Zn	134	78	96	85	92	111
Be	-1	1	1	-1	-1	-1
Co	38	53	34	22	31	15
Cu	24	18	79	52	60	37
Mo	-10	-10	-10	-10	-10	-10
Ni	97	163	59	53	70	7
Sc	21	28	23	19	11	18
Sr	766	468	541	476	644	750
V	169	219	157	147	168	172
Y	21	22	15	10	16	23
Zn	114	78	95	67	74	97
Nb	-5	-5	-5	-5	5	6
Rb	-5	96	7	20	-5	50
Sr	824	459	513	463	689	758
Y	28	22	18	12	22	32
Zr	168	120	122	132	186	200
Th	-10	-10	-10	-10	11	-10
Pr	11	10	4.20		11	15
Sm	6.90	7.50	3.40		7	9.70
Eu	1.90	2.10	1.10		1.90	2.50
Gd	5.30	6.20	2.90		4.70	6.70
Tb	700 B	810 B	500 B		600 B	860 B
Dy	4.20	4.10	2.80		3.30	4.70
Ho	840 B	840 B	560 B		650 B	930 B
Er	2.30	2.10	1.80		1.60	2.50
Tm	320 B	300 B	240 B		230 B	360 B
Yb	2.20	1.90	1.50		1.30	2.40
Lu	300 B	290 B	210 B		190 B	360 B
Ce	88	86	35		84	110
La	38	36	15		33	45
Nd	43	45	18		41	56
Y	23	21	15		18	25

MAJOR OXIDE LISTING

	87MGM-0299	87MGM-0169	87MGM-0137	87MGM-0191	87MGM-0167	87MGM-0293
SiO2	51.70	58.90	64.40	51.20	57.70	60.10
Al2O3	18.80	16.30	15.00	20.80	16.60	16.00
Fe2O3	11.30	7.66	3.87	8.45	9.43	7.01
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	3.03	2.94	2.88	2.83	2.24	1.92
CaO	6.06	5.02	4.17	8.46	6.54	5.79
Na2O	4.25	4.47	3.99	4.01	2.38	5.32
K2O	1.84	1.47	1.85	0.61	1.92	0.47
TiO2	0.97	0.60	0.39	0.71	0.97	0.75
P2O5	0.29	0.22	0.11	0.19	0.32	0.30
MnO	0.17	0.13	0.07	0.11	0.14	0.13
CO2	0.55	0.52	1.82	0.28	0.22	0.19
S	0.04	0.01	0.01	0.72	0.03	0.04
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	0.60	0.60	1.90	1.10	0.40	0.30
TOTAL	99.00	98.30	98.60	98.5	98.60	98.10
S.G.	2.87	2.84	2.71	2.88	2.89	2.84

TRACE ELEMENT LISTING

	87MGM-0299	87MGM-0169	87MGM-0137	87MGM-0191	87MGM-0167	87MGM-0293
Co	24	21	12	28	27	21
Cr	36	15	97	34	19	40
Cu	71	27	23	94	69	77
Ni	39	14	42	32	22	24
Pb	-10	-10	-10	-10	-10	-10
Zn	188	82	71	61	93	89
Be	-1	-1	-1	-1	-1	-1
Co	28	23	11	29	30	
Cu	72	21	21	105	64	
Mo	-10	-10	-10	-10	-10	-10
Ni	46	19	49	38	28	
Sc	13	14	7	13	13	13
Sr	460	528	553	443	363	402
V	172	125	64	174	192	117
Y	17	15	7	12	16	21
Zn	183	73	58	47	74	
Nb	-5	-5	-5	-5	-5	-5
Rb	58	42	44	13	67	10
Sr	509	534	538	465	403	399
Y	28	19	9	16	21	25
Zr	153	171	158	128	154	149
Th	-10	13	-10	12	-10	-10
Pr	7.70		4.60	4.30	7.40	
Sm	5.20		2.50	3.30	5.30	
Eu	1.50		680 B	1	1.50	
Gd	4.30		1.60	2.70	4.10	
Tb	640 B		200 B	390 B	590 B	
Dy	3.90		1.10	2.40	3.30	
Ho	830 B		190 B	520 B	670 B	
Er	2.40		460 B	1.50	1.70	
Tm	330 B		70 B	200 B	250 B	
Yb	2.10		440 B	1.30	1.60	
Lu	290 B		70 B	190 B	220 B	
Ce	59		40	31	54	
La	26		20	13	22	
Nd	29		16	17	29	
Y	23		5.40	14	19	

MAJOR OXIDE LISTING

	87MGM-0086
SiO2	60.60
Al2O3	17.50
Fe2O3	6.54
FeO	00.00
MgO	1.71
CaO	6.27
Na2O	3.46
K2O	0.77
TiO2	0.79
P2O5	0.22
MnO	0.18
CO2	0.71
S	0.03
H2O+	00.00
H2O-	00.00
LOI	1.00
TOTAL	99.00
S.G.	2.78

TRACE ELEMENT LISTING

	87MGM-0086
Co	39
Cr	51
Cu	128
Ni	60
Pb	-10
Zn	76
Be	-1
Co	36
Cu	132
Mo	-10
Ni	63
Sc	21
Sr	426
V	186
Y	11
Zn	61
Nb	-5
Rb	38
Sr	425
Y	16
Zr	134
Th	-10

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES: 13

	MEAN	STD. DEVIATION
SiO2	56.01	4.71
Al2O3	16.59	1.71
Fe2O3	8.46	2.10
FeO	0.00	0.00
MgO	3.26	1.07
CaO	6.76	1.96
Na2O	3.84	0.84
K2O	1.24	0.90
TiO2	0.80	0.23
P2O5	0.29	0.16
MnO	0.14	0.04
CO2	0.95	0.92
S	0.08	0.19
H2O+	0.00	0.00
H2O-	0.00	0.00
LOI	1.42	1.45
TOTAL	98.82	0.58
S.G.	2.84	0.10

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Co	13	27.77	10.31
Cr	13	64.15	55.94
Cu	13	58.85	31.74
Ni	13	49.69	41.19
Pb	13	-10.00	0.00
Zn	13	96.62	33.03
Be	13	-0.69	0.75
Co	12	29.17	11.04
Cu	12	57.08	36.08
Mo	13	-10.00	0.00
Ni	12	57.67	40.88
Sc	13	16.46	5.77
Sr	13	524.62	126.39
V	13	158.62	39.00
Y	13	15.85	4.96
Zn	12	85.08	35.93
Nb	13	-3.38	3.95
Rb	13	33.46	30.17
Sr	13	536.85	136.01
Y	13	20.62	6.60
Zr	13	151.92	24.75
Th	13	-4.92	9.66
Pr	9	8.36	3.71
Sm	9	5.64	2.35
Eu	9	77.06	226.10
Gd	9	4.28	1.67
Tb	9	587.78	204.99
Dy	9	3.31	1.10
Ho	9	670.00	228.14
Er	9	52.88	152.67
Tm	9	255.56	87.34
Yb	9	50.48	146.07
Lu	9	235.56	85.16
Ce	9	65.22	27.82
La	9	27.56	11.04
Nd	9	32.67	14.31
Y	9	18.16	6.05

Table 6: Geochemistry of Intermediate-Felsic Metavolcanics (Unit 4)

Whole Rock Analyses

MAJOR OXIDE LISTING

	87MGM-0598	87MGM-0353	87MGM-0039	87MGM-0161	87MGM-0034	87MGM-0053
SiO2	53.00	56.40	62.90	60.10	60.90	69.10
Al2O3	13.40	16.40	15.70	16.40	14.40	13.10
Fe2O3	17.20	8.72	5.98	7.35	6.52	3.99
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	3.08	3.08	2.24	2.15	2.13	2.13
CaO	8.84	8.75	6.13	5.71	4.08	4.13
Na2O	0.62	2.85	4.54	3.94	4.19	3.54
K2O	0.25	0.24	0.45	1.05	2.24	1.27
TiO2	0.48	0.76	0.41	0.56	0.92	0.47
P2O5	0.13	0.28	0.16	0.17	0.40	0.12
MnO	0.61	0.13	0.08	0.11	0.14	0.07
CO2	0.93	1.31	0.76	1.40	2.41	0.45
S	0.11	0.01	0.01	0.01	0.02	0.07
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	1.10	1.80	0.60	1.30	2.40	0.70
TOTAL	98.70	99.40	99.20	98.80	98.30	98.60
S.G.	3.04	2.87	2.84	2.79	2.69	2.74

TRACE ELEMENT LISTING

	87MGM-0598	87MGM-0353	87MGM-0039	87MGM-0161	87MGM-0034	87MGM-0053
Co	25	27	16	16	9	16
Cr	60	70	41	30	-10	77
Cu	20	7	49	47	11	30
Ni	30	36	28	10	-5	37
Pb	-10	-10	-10	-10	-10	10
Zn	94	99	59	65	82	57
Be	-1	1	-1	-1	-1	-1
Co	25	29	15	16	7	13
Cu	21	9	47	40	6	31
Mo	-10	-10	-10	-10	-10	-10
Ni	37	43	29	16	5	39
Sc	17	23	11	10	15	9
Sr	205	434	745	444	463	726
V	96	164	104	144	77	82
Y	13	21	8	11	25	6
Zn	88	105	45	50	66	46
Nb	-5	-5	-5	-5	7	-5
Rb	-5	-5	8	25	49	36
Sr	215	423	726	504	437	667
Y	12	25	11	14	36	7
Zr	113	160	154	154	252	156
Th	12	11	-10	-10	11	-10
Pr	3	6.40		3.90		4.40
Sm	2.30	4.90		3.10		3
Eu	740 B	1.40		930 B		800 B
Gd	2.30	4		2.40		2.10
Tb	330 B	610 B		350 B		260 B
Dy	1.90	3.40		2.20		1.30
Ho	450 B	710 B		470 B		250 B
Er	1.30	2		1.30		660 B
Tm	190 B	300 B		190 B		80 B
Yb	1.30	1.80		1.30		550 B
Lu	200 B	280 B		200 B		70 B
Ce	27	55		29		35
La	13	24		12		16
Nd	13	26		15		16
Y	12	19		12		6.70

MAJOR OXIDE LISTING

	87MGM-0026	87MGM-1057	87MGM-0328	87MGM-0035	87MGM-0117	87MGM-0354
SiO2	67.80	69.70	62.80	73.00	67.20	64.20
Al2O3	14.80	13.60	15.20	13.80	14.60	16.20
Fe2O3	4.07	2.60	2.89	1.59	5.16	2.62
FeO	00.00	00.00	00.00	00.00	00.00	00.00
MgO	1.98	1.23	0.91	0.74	0.67	0.62
CaO	2.74	2.65	7.70	4.49	3.63	5.61
Na2O	5.21	6.14	3.72	4.78	1.90	5.31
K2O	1.56	0.87	1.00	0.25	2.93	0.73
TiO2	0.36	0.31	0.67	0.35	0.40	0.52
P2O5	0.08	0.10	0.15	0.12	0.27	0.09
MnO	0.08	0.06	0.08	0.07	0.16	0.08
CO2	0.43	1.19	3.12	1.32	1.22	2.33
S	0.01	0.01	0.01	0.01	0.01	0.01
H2O+	00.00	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00	00.00
LOI	0.70	1.20	3.50	1.10	1.40	2.70
TOTAL	99.40	98.50	98.60	100.30	98.30	98.70
S.G.	2.71	2.69	2.73	2.68	2.74	2.70

TRACE ELEMENT LISTING

	87MGM-0026	87MGM-1057	87MGM-0328	87MGM-0035	87MGM-0117	87MGM-0354
Co	10	9	7	-5	10	5
Cr	44	52	10	77	43	48
Cu	31	25	29	22	7	14
Ni	24	19	-5	-5	25	7
Pb	-10	20	-10	-10	13	-10
Zn	42	40	31	37	87	18
Be	-1	-1	1	-1	-1	-1
Co	9	8	9	2	10	
Cu	29	54	29	19	5	
Mo	-10	-10	-10	-10	-10	-10
Ni	24	24	9	9	30	
Sc	6	6	12	6	15	8
Sr	350	598	467	530	733	479
V	66	52	84	52	81	104
Y	6	7	14	4	13	11
Zn	31	43	37	30	76	
Nb	-5	-5	-5	-5	-5	-5
Rb	47	19	24	7	60	27
Sr	390	548	419	506	731	461
Y	11	8	16	8	15	13
Zr	151	146	136	133	183	140
Th	-10	-10	-10	-10	11	-10
Pr			4.40		16	
Sm			3.40		7.50	
Eu			990 B		1.80	
Gd			2.80		4.20	
Tb			420 B		470 B	
Dy			2.30		2.40	
Ho			510 B		450 B	
Er			1.30		1	
Tm			200 B		170 B	
Yb			1.20		1.20	
Lu			160 B		180 B	
Ce			38		125	
La			18		60	
Nd			17		54	
Y			12		14	

MAJOR OXIDE LISTING

	87MGM-0602	87MGM-0316	87MGM-0346	87MGM-0345	87MGM-0324
SiO2	71.50	73.30	73.00	70.60	70.10
Al2O3	15.00	14.60	14.80	15.30	15.00
Fe2O3	1.64	1.10	2.02	1.91	2.21
FeO	00.00	00.00	00.00	00.00	00.00
MgO	0.53	0.50	0.29	0.18	0.11
CaO	2.46	1.93	1.94	2.78	2.03
Na2O	4.76	3.28	5.27	5.00	5.76
K2O	2.36	2.13	1.28	1.33	1.64
TiO2	0.25	0.26	0.39	0.41	0.36
P2O5	0.10	0.07	0.12	0.10	0.14
MnO	0.03	0.03	0.05	0.06	0.05
CO2	0.93	0.68	0.11	0.48	0.98
S	0.01	0.01	0.01	0.01	0.01
H2O+	00.00	00.00	00.00	00.00	00.00
H2O-	00.00	00.00	00.00	00.00	00.00
LOI	1.30	1.40	0.60	0.70	1.60
TOTAL	99.90	98.60	99.70	98.40	99.00
S.G.	2.68	2.69	2.69	2.70	2.68

TRACE ELEMENT LISTING

	87MGM-0602	87MGM-0316	87MGM-0346	87MGM-0345	87MGM-0324
Co	-5	-5	-5	-5	-5
Cr	22	-10	54	60	12
Cu	6	5	8	-5	8
Ni	8	-5	12	10	-5
Pb	-10	-10	-10	-10	-10
Zn	29	15	22	27	23
Be	1	-1	-1	-1	1
Co	6	-1	6	6	4
Cu	6	7	5	6	9
Mo	-10	-10	-10	-10	-10
Ni	13	5	17	16	6
Sc	4	1	3	6	3
Sr	609	376	352	456	1055
V	29	16	33	47	27
Y	5	5	5	7	11
Zn	38	19	31	36	32
Nb	-5	-5	-5	-5	-5
Rb	41	43	21	22	40
Sr	543	365	322	399	951
Y	6	6	8	10	12
Zr	129	134	125	132	162
Th	-10	-10	-10	-10	10
Pr	4.50	2.50	3	3.10	17
Sm	2.50	1.50	1.90	2	8.30
Eu	720 B	440 B	610 B	660 B	1.90
Gd	1.50	950 B	1.50	1.50	4.50
Tb	180 B	110 B	180 B	220 B	510 B
Dy	800 B	550 B	830 B	1.10	2.40
Ho	150 B	90 B	140 B	200 B	400 B
Er	380 B	220 B	330 B	520 B	960 B
Tm	70 B	-50 B	-50 B	60 B	130 B
Yb	390 B	240 B	340 B	440 B	740 B
Lu	60 B	-50 B	-50 B	60 B	120 B
Ce	40	22	29	31	155
La	20	11	15	16	81
Nd	17	8.50	11	12	56
Y	4	3	4	6.30	11

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Co	17	7.06	10.78
Cr	17	40.00	27.36
Cu	17	18.47	15.10
Ni	17	13.00	15.04
Pb	17	-5.71	9.73
Zn	17	48.65	27.93
Be	17	-0.53	0.87
Co	16	10.25	7.91
Cu	16	20.19	16.37
Mo	17	-10.00	0.00
Ni	16	20.12	12.57
Sc	17	9.12	5.83
Sr	17	530.71	199.83
V	17	74.00	40.73
Y	17	10.12	5.85
Zn	16	48.31	23.61
Nb	17	-4.29	2.91
Rb	17	27.00	18.74
Sr	17	506.29	178.65
Y	17	12.82	7.56
Zr	17	150.59	31.04
Th	17	-3.82	9.87
Pr	11	6.20	5.21
Sm	11	3.67	2.29
Eu	11	535.92	373.23
Gd	11	88.80	285.63
Tb	11	330.91	157.89
Dy	11	199.73	345.35
Ho	11	347.27	193.96
Er	11	279.72	326.90
Tm	11	117.27	107.99
Yb	11	246.07	265.13
Lu	11	111.82	105.05
Ce	11	53.27	44.25
La	11	26.00	22.79
Nd	11	22.32	16.78
Y	11	9.45	5.02

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES: 17

	MEAN	STD. DEVIATION
SiO2	66.21	6.08
Al2O3	14.84	1.00
Fe2O3	4.56	3.96
FeO	0.00	0.00
MgO	1.33	1.00
CaO	4.45	2.32
Na2O	4.17	1.42
K2O	1.27	0.80
TiO2	0.46	0.18
P2O5	0.15	0.09
MnO	0.11	0.13
CO2	1.18	0.79
S	0.02	0.03
H2O+	0.00	0.00
H2O-	0.00	0.00
LOI	1.42	0.80
TOTAL	98.96	0.59
S.G.	2.74	0.09

Table 7: Geochemistry of Metamorphosed Mafic Intrusive Rocks (Unit 7)

Whole Rock Analyses

MAJOR OXIDE LISTING

	87MGM-0185	87MGM-0043
SiO2	47.60	51.00
Al2O3	15.90	16.50
Fe2O3	11.40	10.40
FeO	00.00	00.00
MgO	8.01	5.56
CaO	12.20	9.80
Na2O	1.46	3.11
K2O	0.19	0.74
TiO2	0.61	0.58
P2O5	0.08	0.07
MnO	0.19	0.19
CO2	0.12	0.07
S	0.07	0.03
H2O+	00.00	00.00
H2O-	00.00	00.00
LOI	1.20	0.70
TOTAL	98.80	98.60
S.G.	3.03	2.95

TRACE ELEMENT LISTING

	87MGM-0185	87MGM-0043
Co	45	36
Cr	367	111
Cu	71	80
Ni	95	48
Pb	-10	-10
Zn	75	87
Be	-1	-1
Co	45	33
Cu	70	80
Mo	-10	-10
Ni	105	46
Sc	40	34
Sr	297	290
V	251	202
Y	13	19
Zn	65	65
Nb	-5	-5
Rb	-5	20
Sr	308	289
Y	16	24
Zr	82	109
Th	-10	-10

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Co	2	40.50	6.36
Cr	2	239.00	181.02
Cu	2	75.50	6.36
Ni	2	71.50	33.23
Pb	2	-10.00	0.00
Zn	2	81.00	8.49
Be	2	-1.00	0.00
Co	2	39.00	8.49
Cu	2	75.00	7.07
Mo	2	-10.00	0.00
Ni	2	75.50	41.72
Sc	2	37.00	4.24
Sr	2	293.50	4.95
V	2	226.50	34.65
Y	2	16.00	4.24
Zn	2	65.00	0.00
Nb	2	-5.00	0.00
Rb	2	7.50	17.68
Sr	2	298.50	13.44
Y	2	20.00	5.66
Zr	2	95.50	19.09
Th	2	-10.00	0.00

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES: 2

	MEAN	STD. DEVIATION
SiO_2	49.30	2.40
Al_2O_3	16.20	0.42
Fe_2O_3	10.90	0.71
FeO	0.00	0.00
MgO	6.78	1.73
CaO	11.00	1.70
Na_2O	2.28	1.17
K_2O	0.47	0.39
TiO_2	0.60	0.02
P_2O_5	0.08	0.01
MnO	0.19	0.00
CO_2	0.09	0.04
S	0.05	0.03
H_2O+	0.00	0.00
H_2O-	0.00	0.00
LOI	0.95	0.35
TOTAL	98.70	0.15
S.G.	2.99	0.06

Table 8: Geochemistry of Metamorphosed Felsic-Intermediate Intrusive Rocks (Unit 10)

Whole Rock Analyses

MAJOR OXIDE LISTING

	87MGM-0288	87MGM-0116	87MGM-0440
SiO2	65.20	64.10	69.90
Al2O3	14.40	16.90	16.90
Fe2O3	8.41	4.80	0.71
FeO	00.00	00.00	00.00
MgO	1.11	0.58	0.26
CaO	5.27	2.38	2.69
Na2O	1.40	4.89	4.39
K2O	1.45	3.46	2.57
TiO2	0.78	0.38	0.35
P2O5	0.23	0.28	0.15
MnO	0.16	0.08	0.02
CO2	0.41	0.54	0.41
S	0.01	0.04	0.10
H2O+	00.00	00.00	00.00
H2O-	00.00	00.00	00.00
LOI	0.80	1.00	1.20
TOTAL	99.20	98.80	99.10
S.G.	2.82	2.71	2.69

TRACE ELEMENT LISTING

	87MGM-0288	87MGM-0116	87MGM-0440
Co	10	11	5
Cr	-10	52	41
Cu	7	27	29
Ni	-5	20	16
Pb	25	10	12
Zn	180	92	15
Be	2	-1	-1
Co	11	11	
Cu	9	26	
Mo	-10	-10	-10
Ni	6	27	
Sc	12	8	-1
Sr	389	1260	609
V	14	86	63
Y	44	12	7
Zn	182	84	
Nb	-5	-5	-5
Rb	36	76	73
Sr	373	1280	603
Y	51	12	7
Zr	245	187	178
Th	-10	16	15
Pr	11		
Sm	8.40		
Eu	2.40		
Gd	8.80		
Tb	1.40		
Dy	7.80		
Ho	1.80		
Er	4.60		
Tm	730 B		
Yb	4.70		
Lu	730 B		
Ce	97		
La	42		
Nd	48		
Y	45		

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES: 3

	MEAN	STD. DEVIATION
SiO2	66.40	3.08
Al2O3	16.07	1.44
Fe2O3	4.64	3.85
FeO	0.00	0.00
MgO	0.65	0.43
CaO	3.45	1.59
Na2O	3.56	1.89
K2O	2.49	1.01
TiO2	0.50	0.24
P2O5	0.22	0.07
MnO	0.09	0.07
CO2	0.45	0.08
S	0.05	0.05
H2O+	0.00	0.00
H2O-	0.00	0.00
LOI	1.00	0.20
TOTAL	99.03	0.21
S.G.	2.74	0.07

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Co	3	8.67	3.21
Cr	3	27.67	33.08
Cu	3	21.00	12.17
Ni	3	10.33	13.43
Pb	3	15.67	8.14
Zn	3	95.67	82.56
Be	3	0.00	1.73
Co	2	11.00	0.00
Cu	2	17.50	12.02
Mo	3	-10.00	0.00
Ni	2	16.50	14.85
Sc	3	6.33	6.66
Sr	3	752.67	452.92
V	3	54.33	36.77
Y	3	21.00	20.07
Zn	2	133.00	69.30
Nb	3	-5.00	0.00
Rb	3	61.67	22.28
Sr	3	752.00	471.50
Y	3	23.33	24.09
Zr	3	203.33	36.36
Th	3	7.00	14.73
Pr	1	11.00	0.00
Sm	1	8.40	0.00
Eu	1	2.40	0.00
Gd	1	8.80	0.00
Tb	1	1.40	0.00
Dy	1	7.80	0.00
Ho	1	1.80	0.00
Er	1	4.60	0.00
Tm	1	730.00	0.00
Yb	1	4.70	0.00
Lu	1	730.00	0.00
Ce	1	97.00	0.00
La	1	42.00	0.00
Nd	1	48.00	0.00
Y	1	45.00	0.00

Table 9: Geochemistry of Metamorphosed Alkalic Mafic Intrusive Rocks (Unit 11)

Whole Rock Analyses

MAJOR OXIDE LISTING

	86MGM-1068	86MGM-1070	86MGM-0443
SiO2	49.60	50.20	44.30
Al2O3	10.70	13.60	10.60
Fe2O3	8.32	14.50	17.90
FeO	00.00	00.00	00.00
MgO	10.70	3.39	4.05
CaO	8.76	10.40	8.38
Na2O	2.48	2.77	4.60
K2O	2.91	0.24	1.89
TiO2	1.00	1.96	0.88
P2O5	0.75	0.18	0.89
MnO	0.12	0.28	0.19
CO2	3.04	1.84	5.35
S	0.02	0.38	0.19
H2O+	00.00	00.00	00.00
H2O-	00.00	00.00	00.00
LOI	4.30	1.50	5.20
TOTAL	99.60	99.00	98.90
S.G.	2.88	2.99	2.90

TRACE ELEMENT LISTING

	86MGM-1068	86MGM-1070	86MGM-0443
Co	42	42	35
Cr	29	77	-10
Cu	104	89	25
Ni	93	41	5
Pb	28	-10	-10
Zn	79	144	96
Nb	-5	-5	-5
Rb	147	-5	105
Sr	349	151	533
Y	21	46	24
Zr	125	132	186
Th	10	-10	-10

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES: 3

	MEAN	STD. DEVIATION
SiO2	48.03	3.25
Al2O3	11.63	1.70
Fe2O3	13.57	4.86
FeO	0.00	0.00
MgO	6.05	4.04
CaO	9.18	1.07
Na2O	3.28	1.15
K2O	1.68	1.35
TiO2	1.28	0.59
P2O5	0.61	0.38
MnO	0.20	0.08
CO2	3.41	1.78
S	0.20	0.18
H2O+	0.00	0.00
H2O-	0.00	0.00
LOI	3.67	1.93
TOTAL	99.17	0.38
S.G.	2.92	0.06

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Co	3	39.67	4.04
Cr	3	32.00	43.58
Cu	3	72.67	41.96
Ni	3	46.33	44.24
Pb	3	2.67	21.94
Zn	3	106.33	33.71
Nb	3	-5.00	0.00
Rb	3	82.33	78.49
Sr	3	344.33	191.04
Y	3	30.33	13.65
Zr	3	147.67	33.38
Th	3	-3.33	11.55

Table 10. Sample Descriptions-Whole Rock Geochemistry; Monument Bay Area.

Sample No. (87MGM-xx)	Lithology
Unit 1: Mafic-ultramafic metavolcanics	
212	pillowed basaltic komatiite
235	plag-phyric pillow basalt; 25% plag (2-4mm)
405	massive basalt; 6 m below pillow cntct
406	pillow basalt
584a	core of pillow
1173	mafic tuff/lap tuff; pyroclastic flow?
1262	var'c pillowed komatiite; poly suture, amygd'l
1436	plag-phyric pillow basalt
1437	pillowed basalt; top of compound flow
1438	massive basalt; base of compound flow
1439	massive basalt; px spinifex
1442	pillowed basaltic komatiite
1443	pillow basalt; "leopard rock"
Unit 2: Mafic metavolcanics	
30	tuff; qtz-plag-bio sch, 30-35% biotite
38	cpx cum tuff; ultramafic
44	trach'c clast in het t.bx.; 20% plag, 1% cpx
45	trach'c clast in het t.bx.; 15% plag
46	cpx(5-7%)- plag(10%)-phyric pillow basalt
51	alkalic mafic-int tuff
70	mafic hyaloclastite; amygd'l
164	alkalic tuff; cse bedded, gabbroic-looking
177	cpx- plag-phyric flow; lava lake?
187	mafic tuff; magnetic
242	cpx-phyric basalt; massive flow
309	cpx-phyric pillowed flow
321	mafic tuffs; amph'd
325	cpx-phyric pillow basalt; epidotized
329	ves pillowed andesite; aphyric
397	amygd'l cpx-phyric basalt clast in pillow bx
424	cpx basalt; massive, autobx'd flow
451	trachytic clast in mono t.bx.
1047	cpx-phyric pillow basalt
1058	massive cpx-phyric flow
1431	cpx-phyric mafic tuffs
Unit 3: Intermediate metavolcanics	
42	int clast;maf-int t.bx.;6x30cm, cpx cum clot
49	lap tuff;ash flow?, cpx- plag-phyric, pum's?
86	plag(10%)-phyric pillow basalt; 5-10% gar blasts
137	cpx-phyric andesite; cc amygd?, bio wisps, sil'd?
167	plagioclase-phyric pillowed flow
169	plagioclase-phyric massive flow
191	intermediate tuff; 15-20% plag phenos (trachytic)
220	plag-phyric int dyke; trachytic
293	plag-phyric pillowed flow

299	plag-phyric pillowed andesite
300	amph'd 299
1306	plag-phyric pillowed flow
1358	plag-phyric pillowed flow; amygd'l

Unit 4: Intermediate-felsic metavolcanics

26	intermediate tuff
34	feld porphyry; intrusive? ash flow?
35	aphyric int-fel clast in het t.bx.
39	aphyric int clast in het t.bx.; just north of 38
53	intermediate cpx-phyric clast in het t.bx.
117	plag-phyric clast in het t.bx.
161	int clast in het int-felsic t bx; cpx clot
247	mono int lap tuff; pumice clasts?
316	mono int-fel t.bx.; qfp clasts
324	felsic clast in het t.bx.
328	aphyric int-fel clast in t.bx.
345	qtz-feld porphyry clast in het t.bx.
346	feld porphyry clast in het t.bx.; adj to 345
353	int clast in het t.bx.; hb-brg (blastic? porph?)
354	aphyric int clast in het t.bx.
598	gar-amph rock; 10-25% gar blasts
602	qtz-feld porphyry; massive flow? sill?
1057	rounded clast in conglomerate

Unit 7: Mafic intrusive rocks

43	mafic fsp porphyry sill; fsp=Bukete I.
185	gabbro dyke

Unit 8: Intermediate-felsic intrusive rocks

116	massive feldspar porphyry
288	qtz-plag-bio-gar gneiss; alt'd intrusion?
440	feldspar porphyry sill

Unit 10: Alkalic mafic intrusive rocks (86MGM-xx)

443	cse-gr monzodiorite phase; lamprophyric complex
1068	chill margin; lamprophyric complex
1070	hornblende porphyry; lamprophyric complex

Table 11: Assay Results

TRACE ELEMENT LISTING

	87MGM-0001	87MGM-001D	87MGM-0002	87MGM-0003	87MGM-003D	87MGM-003D
Ag	-2	-2	-2	-2		
As	7	8.50	15.50	1		
Au	8 B	9 B	7 B	70 B	65 B	75 B
Cu	238	240	75	260		
Pb	18	20	34	-10		
Zn	1300	1315	850	1540		

TRACE ELEMENT LISTING

	87MGM-0004	87MGM-004D	87MGM-004D	87MGM-0005	87MGM-005D	87MGM-005D
Ag	-2			-2		
As	2			3.50		
Au	9999 B	110 B	460 B	105 B	105 B	100 B
Cu	108			164		
Pb	-10			-10		
Zn	295			2420		

TRACE ELEMENT LISTING

	87MGM-0006	87MGM-0007	87MGM-0011	87MGM-0028	87MGM-0052	87MGM-0069
Ag	-2	-2	-2	-2	-2	-2
As	1	2	-1	-1	2	1
Au	16 B	9 B	-2 B	3 B	-2 B	-2 B
Cu	510	51	208	268	23	18
Pb	23	-10	-10	-10	-10	-10
Zn	2680	138	78	143	14	28

TRACE ELEMENT LISTING

	87MGM-0071	87MGM-0072	87MGM-0075	87MGM-0077	87MGM-0080	87MGM-0089
Ag	-2	-2	-2	-2	-2	-2
As	51	1.50	1	-1	-1	1
Au	-2 B	-2 B	-2 B	3 B	-2 B	-2 B
Cu	25	143	9	260	158	63
Pb	54	-10	-10	-10	-10	11
Zn	84	81	-10	105	405	235

TRACE ELEMENT LISTING

	87MGM-0090	87MGM-0095	87MGM-0096	87MGM-0103	87MGM-0106	87MGM0106D
Ag	-2	-2	-2	-2	-2	-2
As	-1	1.50	-1	2.50	1	1
Au	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Cu	42	24	22	19	39	39
Pb	-10	10	11	-10	-10	-10
Zn	155	66	60	48	47	47

TRACE ELEMENT LISTING

	87MGM-0110		87MGM-0111		87MGM-0112		87MGM-0113		87MGM-0121		87MGM-0123	
Ag	-2		-2		-2		-2		-2		-2	
As	-1		1		-1		1.50		10.50		2	
Au	-2	B	-2	B	-2	B	10	B	-2	B	-2	B
Cu	19		13		12		21		11		12	
Pb	10		11		-10		13		-10		-10	
Zn	42		24		55		52		14		20	

TRACE ELEMENT LISTING

	87MGM-0133		87MGM-0134		87MGM-0136		87MGM-0138		87MGM0138D		87MGM-0140	
Ag	-2		-2		-2		-2		-2		-2	
As	-1		-1		3.50		1.50		1.50		-1	
Au	-2	B	-2	B	-2	B	-2	B	-2	B	-2	B
Cu	43		10		10		131		129		77	
Pb	-10		-10		-10		-10		-10		-10	
Zn	70		51		106		81		82		108	

TRACE ELEMENT LISTING

	87MGM-0141		87MGM-0143		87MGM-0147		87MGM-0148		87MGM-148A		87MGM-0149	
Ag	-2		-2		-2		-2		-2		-2	
As	1		-1		-1		-1		-1		-1	
Au	15	B	2	B	-2	B	-2	B	2	B	11	B
Cu	27		117		215		63		424		508	
Pb	10		-10		-10		-10		16		31	
Zn	62		81		165		155		434		1363	

TRACE ELEMENT LISTING

	87MGM-0150		87MGM-0154		87MGM-0155		87MGM-0156		87MGM-0157		87MGM-0158	
Ag	-2		-2		-2		-2		-2		-2	
As	-1		-1		20		-1		1		1	
Au	-2	B	2	B	4	B	-2	B	-2	B	10	B
Cu	129		116		33		33		38		123	
Pb	13		92		-10		-10		-10		-10	
Zn	218		71		115		118		120		243	

TRACE ELEMENT LISTING

	87MGM0158D		87MGM-0163		87MGM-0165		87MGM-0175		87MGM-0179		87MGM-0184	
Ag	-2		-2		-2		-2		-2		-2	
As	1		-1		-1		-1		-1		7.50	
Au	9	B	-2		2	B	-2		2	B	10	B
Cu	122		69		89		89		38		188	
Pb	-10		-10		-10		-10		-10		-10	
Zn	240		158		258		63		68		271	

TRACE ELEMENT LISTING

	87MGM-0186	87MGM-0190	87MGM-0194	87MGM-0199	87MGM-0200	87MGM-0206
Ag	-2	2	-2	-2	-2	-2
As	-1	-1	-1	-1	-1	-1
Au	-2	60 B	6 B	3 B	-2	40 B
Cu	46	17	371	105	16	22
Pb	-10	-10	-10	-10	-10	-10
Zn	59	22	52	36	156	39

TRACE ELEMENT LISTING

	87MGM-0208	87MGM-0209	87MGM-0211	87MGM-0213	87MGM-0214	87MGM-0215
Ag	-2	-2	-2	-2	-2	-2
As	25	12	3	3	7	4.50
Au	65 B	870 B	65 B	12 B	250 B	100 B
Cu	44	8	203	193	48	20
Pb	-10	-10	-10	-10	-10	-10
Zn	11	40	21	45	35	15

TRACE ELEMENT LISTING

	87MGM-0216	87MGM-0217	87MGM-0218	87MGM-0224	87MGM-0227	87MGM-0243
Ag	-2	-2	-2	-2	-2	-2
As	8	3	3.50	8	2.50	10
Au	160 B	335 B	18 B	55 B	2 B	140 B
Cu	18	329	25	9	24	13
Pb	-10	-10	-10	-10	-10	16
Zn	11	22	31	13	48	24

TRACE ELEMENT LISTING

	87MGM-0255	87MGM-0256	87MGM-0260	87MGM-0277	87MGM-0289	87MGM-0295
Ag	-2	-2	-2	-2	-2	-2
As	-1	1.50	-1	1	25	-1
Au	-2	2 B	-2	5 B	15 B	-2
Cu	20	10	22	45	80	14
Pb	-10	-10	-10	-10	-10	-10
Zn	34	42	59	-10	24	79

TRACE ELEMENT LISTING

	87MGM-0297	87MGM-0298	87MGM-0304	87MGM-0331	87MGM-0340	87MGM-0347
Ag	-2	-2	-2	-2	-2	-2
As	1.50	-1	-1	-1	-1	1
Au	-2	-2	9 B	2 B	4 B	2 B
Cu	35	53	61	62	83	49
Pb	-10	-10	-10	-10	-10	-10
Zn	34	91	73	745	80	198

TRACE ELEMENT LISTING

	87MGM-0348	87MGM-0349	87MGM-0350	87MGM-0351	87MGM-0365	87MGM-0366
Ag	-2	-2	-2	-2	-2	-2
As	1	1	33	35	-1	-1
Au	3 B	4 B	14 B	25 B	23 B	10 B
Cu	16	44	12	70	90	15
Pb	-10	-10	-10	-10	-10	-10
Zn	54	67	20	98	39	18

TRACE ELEMENT LISTING

	87MGM-0367	87MGM-367D	87MGM-367D	87MGM-0368	87MGM-368D	87MGM-368D
Ag	-2			-2		
As	2			1		
Au	120 B	130 B	120 B	90 B	85 B	95 B
Cu	9			25		
Pb	-10			-10		
Zn	12			73		

TRACE ELEMENT LISTING

	87MGM-0372	87MGM-372D	87MGM-372D	87MGM-0375	87MGM-375D	87MGM-375D
Ag	-2			12		
As	3			15		
Au	400 B	415 B	400 B	215 B	220 B	210 B
Cu	9			1230		
Pb	-10			-10		
Zn	21			26		

TRACE ELEMENT LISTING

	87MGM-0376	87MGM-376D	87MGM-376D	87MGM-0377	87MGM-377D	87MGM-377D
Ag	-2			-2		
As	1			2		
Au	160 B	160 B	165 B	330 B	330 B	330 B
Cu	13			51		
Pb	-10			-10		
Zn	40			27		

TRACE ELEMENT LISTING

	87MGM-0382	87MGM-382D	87MGM-382D	87MGM-0384	87MGM-384D	87MGM-384D
Ag	-2			-2		
As	11.50			3.50		
Au	225 B	225 B	225 B	250 B	255 B	245 B
Cu	18			49		
Pb	-10			-10		
Zn	33			49		

TRACE ELEMENT LISTING

	87MGM-0385	87MGM-385D	87MGM-385D	87MGM-0386	87MGM-386D	87MGM-386D
Ag	2			-2		
As	6			2.50		
Au	1680 B	2000 B	1360 B	90 B	100 B	85 B
Cu	162			27		
Pb	-10			-10		
Zn	58			53		

TRACE ELEMENT LISTING

	87MGM-0388	87MGM-388D	87MGM-388D	87MGM-0389	87MGM-389D	87MGM-389D
Ag	-2			-2		
As	4			1		
Au	585 B	590 B	580 B	150 B	165 B	140 B
Cu	20			16		
Pb	-10			-10		
Zn	72			78		

TRACE ELEMENT LISTING

	87MGM-0393	87MGM-0404	87MGM-0417	87MGM-0430	87MGM-0431	87MGM-0433
Ag	-2	-2	-2	-2	-2	-2
As	-1	63	2	1.50	2.50	5
Au	2 B	4 B	14 B	3 B	12 B	755 B
Cu	41	77	175	41	290	460
Pb	-10	-10	-10	-10	-10	-10
Zn	49	63	85	86	49	-10

TRACE ELEMENT LISTING

	87MGM-433D	87MGM-433D	87MGM-0436	87MGM-436D	87MGM-436D	87MGM-0437
Ag			-2			-2
As			5.50			1
Au	700 B	810 B	530 B	420 B	640 B	24 B
Cu			26			32
Pb			-10			-10
Zn			-10			-10

TRACE ELEMENT LISTING

	87MGM-0438	87MGM-0442	87MGM0442D	87MGM-0450	87MGM0450D	87MGM-0457
Ag	-2	-2	-2	11	10	-2
As	1	6.50	6	25	26	1
Au	11 B	-2 B	-2 B	6 B	7 B	2 B
Cu	15	45	43	61	61	56
Pb	-10	149	145	880	855	-10
Zn	10	420	413	190	180	89

TRACE ELEMENT LISTING

	87MGM0457D	87MGM-0461	87MGM0461D	87MGM-0462	87MGM0462D	87MGM-0463
Ag	-2	-2	-2	-2	-2	-2
As	1	5	5	1	1	5
Au	4 B	23 B	22 B	-2 B	-2 B	23 B
Cu	61	95	95	14	15	60
Pb	-10	-10	-10	-10	-10	-10
Zn	88	67	69	14	16	19

TRACE ELEMENT LISTING

	87MGM-0464	87MGM-0468	87MGM-0469	87MGM-469D	87MGM-469D	87MGM-0478
Ag	-2	-2	3			-2
As	1.50	1.50	1.50			1
Au	10 B	-2 B	170 B	170 B	170 B	11 B
Cu	28	100	89			51
Pb	-10	-10	-10			-10
Zn	16	28	44			72

TRACE ELEMENT LISTING

	87MGM-0481	87MGM-0488	87MGM-0507	87MGM-0508	87MGM-0514	87MGM-0517
Ag	-2	2	-2	-2	-2	-2
As	8.50	2.50	3	47	1	-1
Au	2 B	-2 B	13 B	-2 B	3 B	5 B
Cu	42	99	25	19	34	52
Pb	-10	-10	12	22	11	-10
Zn	81	128	57	35	27	15

TRACE ELEMENT LISTING

	87MGM-0519	87MGM-0520	87MGM-0521	87MGM-0522	87MGM-0523	87MGM-0525
Ag	-2	2	-2	-2	-2	-2
As	2.50	1.50	1	1	90	-1
Au	-2 B	5 B	-2 B	4 B	13 B	-2 B
Cu	38	89	31	50	39	73
Pb	-10	-10	-10	-10	-10	-10
Zn	240	147	91	112	54	94

TRACE ELEMENT LISTING

	87MGM-0526	87MGM-0533	87MGM-0540	87MGM-0542	87MGM-0544	87MGM-0545
Ag	-2	-2	-2	-2	-2	-2
As	-1	2.50	1	-1	-1	-1
Au	-2 B	-2 B	-2 B	2 B	-2 B	-2 B
Cu	160	23	24	37	12	15
Pb	-10	-10	-10	-10	-10	-10
Zn	198	116	93	73	80	68

TRACE ELEMENT LISTING

	87MGM-0549	87MGM-0550	87MGM-0551	87MGM-0552	87MGM-0553	87MGM-0555
Ag	-2	-2	-2	-2	-2	-2
As	-1	3.50	-1	3	-1	1
Au	-2 B	-2 B	-2 B	-2 B	-2 B	4 B
Cu	114	36	43	60	67	39
Pb	-10	-10	-10	-10	21	-10
Zn	122	85	63	24	88	137

TRACE ELEMENT LISTING

	87MGM-0562	87MGM-0567	87MGM-567D	87MGM-567D	87MGM-0585	87MGM-0586
Ag	-2	2			-2	-2
As	1.50	-1			2	1.50
Au	8 B	120 B	100 B	140 B	-2	-2
Cu	51	78			23	33
Pb	-10	-10			-10	-10
Zn	84	111			42	33

TRACE ELEMENT LISTING

	87MGM-0589
Ag	-2
As	1.50
Au	2 B
Cu	110
Pb	-10
Zn	325

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	155	-1.59	1.95
As	155	4.48	11.68
Au	193	162.12	757.40
Cu	155	86.34	132.15
Pb	155	7.66	100.97
Zn	155	160.38	361.45

Table 12. Anomalous Assay Results[a,b]

Map #[c]	Au	Ag	As	Cu	Zn
1	500	nd[d]	2.0	108	295
2	105	nd	3.5	164	2420
3a	870	nd	12.0	8	40
3b	400	nd	11.0	14	23
4a	250	nd	7.0	48	35
4b	100	nd	4.5	20	15
4c	160	nd	8.0	18	11
5	335	nd	3.0	329	22
6	140	nd	10.0	13	24
7	120	nd	2.0	9	12
8	400	nd	3.0	9	21
9	215	12	15.0	1230	26
10	160	nd	1.0	13	40
11	330	nd	2.0	51	27
12	225	nd	11.5	18	33
13	250	nd	3.5	49	49
14	1680	2	6.0	162	58
15	585	nd	4.0	20	72
16	150	nd	1.0	16	78
17	755	nd	5.0	460	nd
18	530	nd	5.5	26	nd
19	170	3	1.5	89	44
20	120	2	nd	78	111
21	100	nd	1.0	53	41
22	1000	nd	nd	305	155
23a	290	nd	2.0	260	32
23b	52.3ppm	38	nd	1.08%	216
23c	4355	7	nd	4050	263
23d	6815	19	nd	1.24%	305
23e	4145	2	nd	1040	180
23f	1400	8	nd	4225	195
23g	5200	24	nd	1.65%	313
23h	15.7ppm	32	1.0	710	103
23i	10.0ppm	2	nd	610	158
24	235	8	11.0	36	333

a) Results in ppm (Ag, As, Cu, Zn), ppb (Au), except as noted.

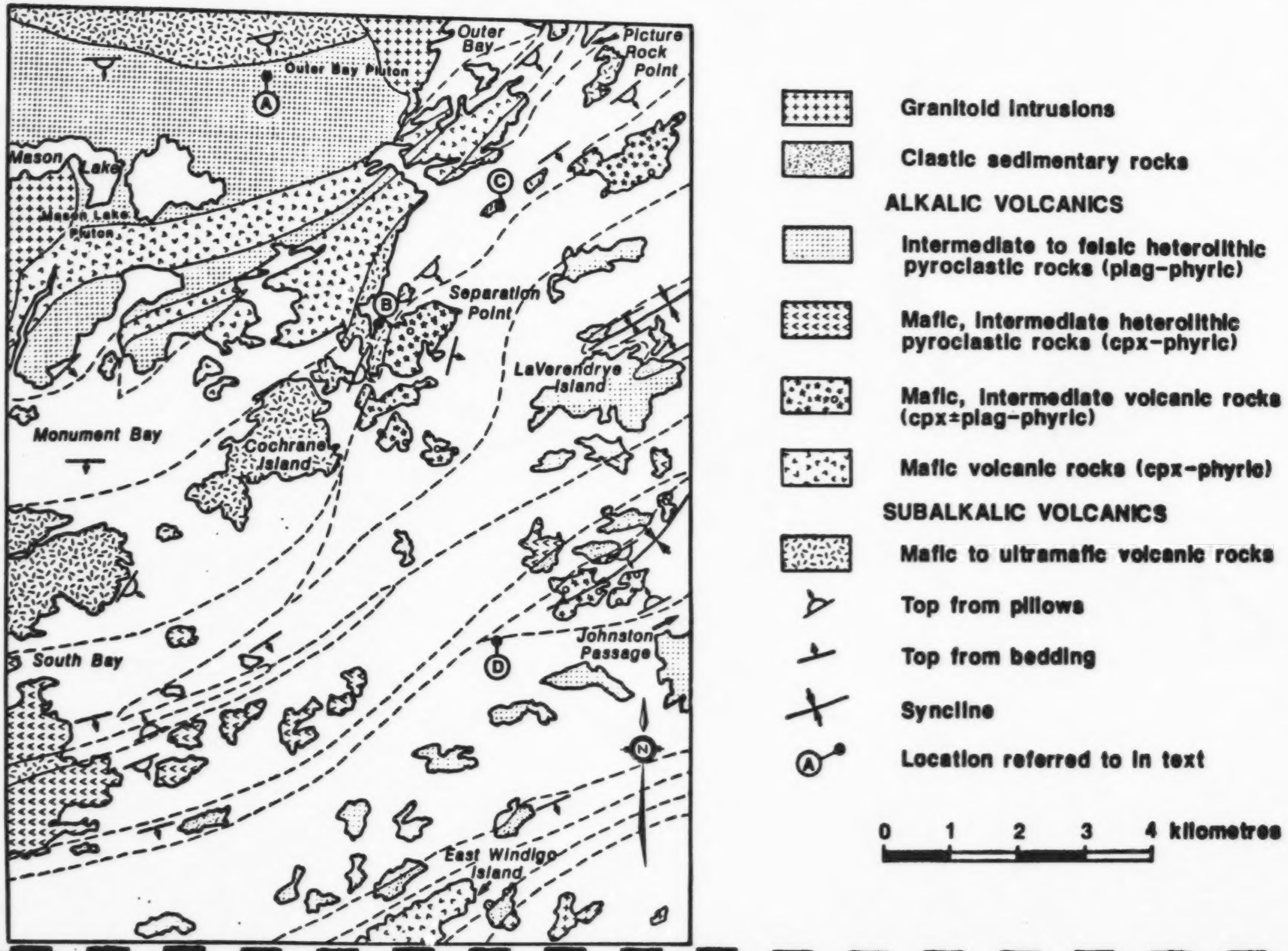
b) Pb analyses: all "nd"[c] except #24 (380 ppm) and #6 (16 ppm).

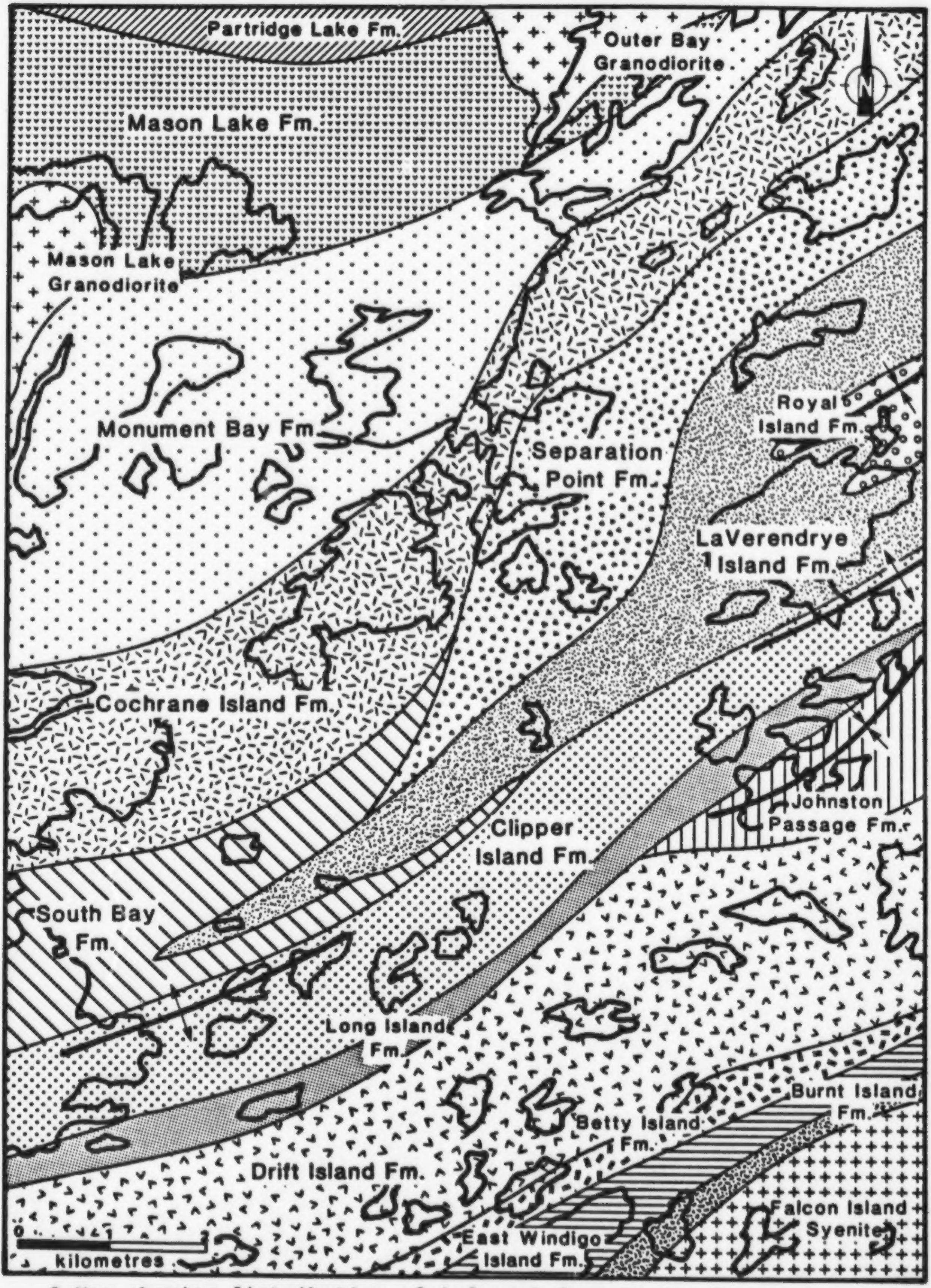
c) Map # refers to location as annotated on Preliminary Map (back pocket).

d) nd - not detected.

FIGURES

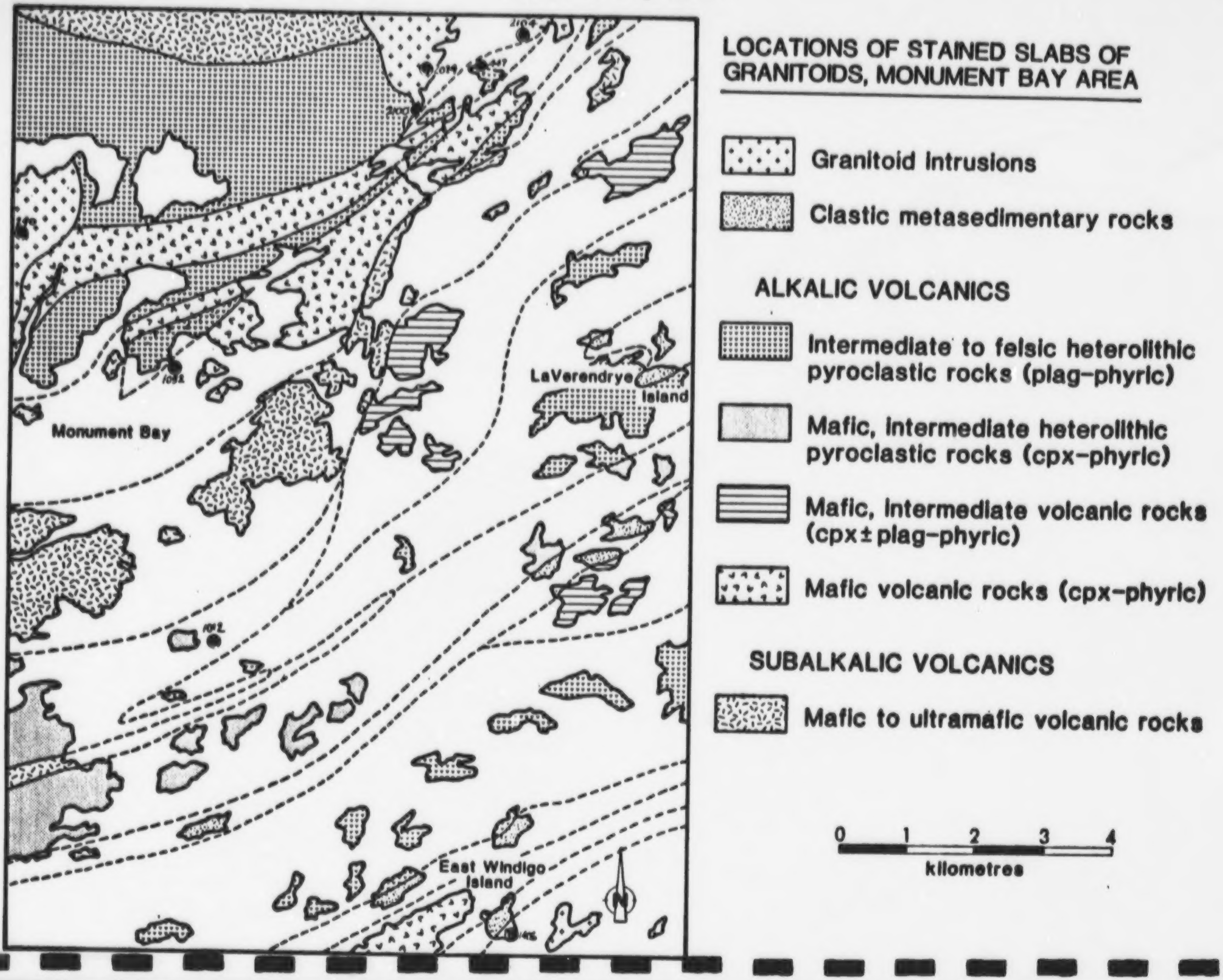
2-Generalized geology of the Monument Bay Area.

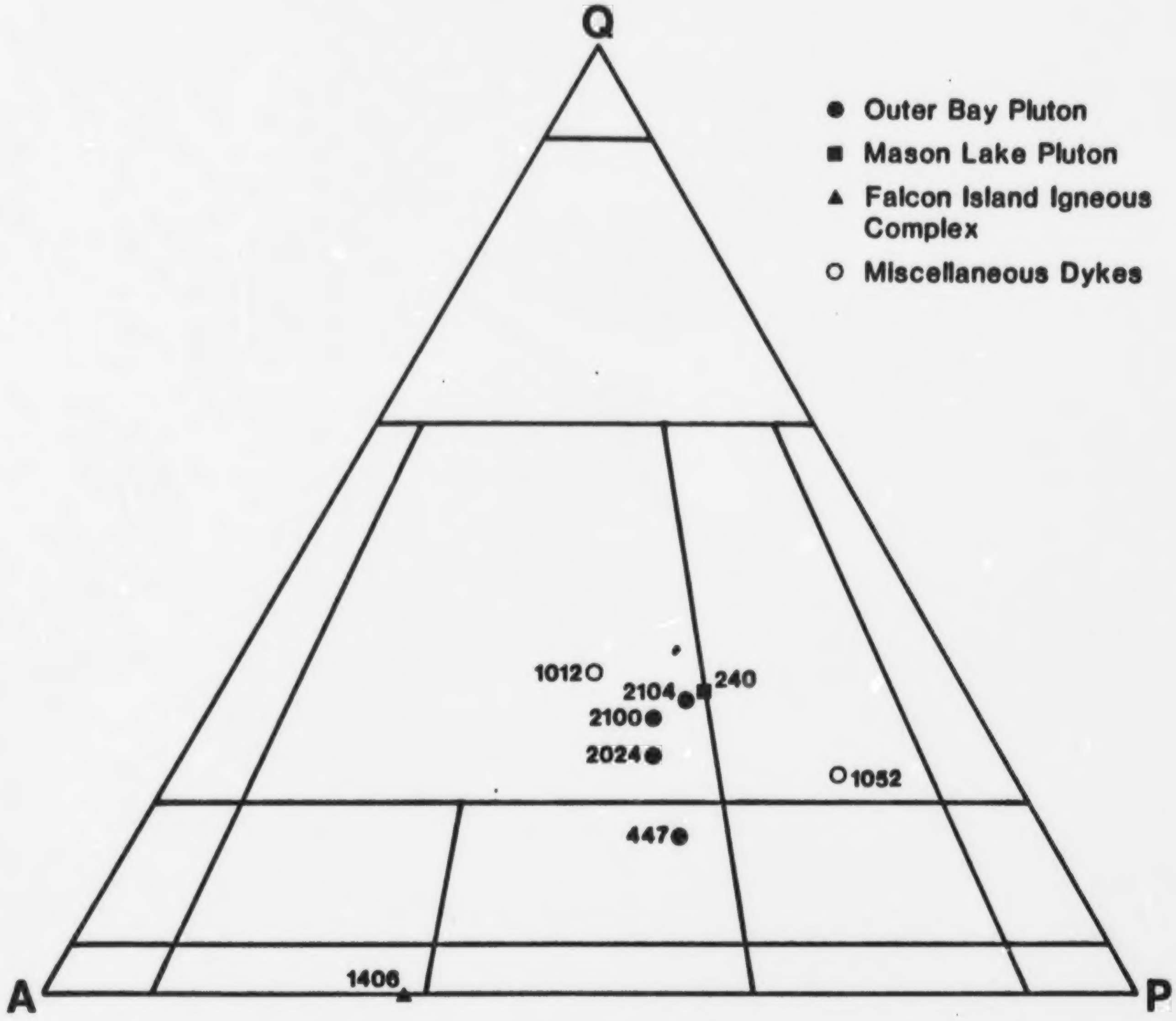

Outer Bay
Picture Rock Point
Outer Bay Pluton
A
Mason Lake
Mason Lake Pluton
C
B
Separation Point
LaVerendrye Island
Monument Bay
Cochrane Island
South Bay
D
Johnston Passage
N
East Windigo Island
Granitoid intrusions
Clastic sedimentary rocks
ALKALIC VOLCANICS
Intermediate to felsic heterolithic pyroclastic rocks (plag-phyric)
Mafic, intermediate heterolithic pyroclastic rocks (cpx-phyric)
Mafic, intermediate volcanic rocks (cpx±plag-phyric)
Mafic volcanic rocks (cpx-phyric)
SUBALKALIC VOLCANICS
Mafic to ultramafic volcanic rocks
Top from pillows
Top from bedding
Syncline
Location referred to in text
0
1
2
3
4 kilometres


Partridge Lake Fm.
Outer Bay Granodiorite
N
Mason Lake Fm.
Mason Lake Granodiorite
Monument Bay Fm.
Separation Point Fm.
Royal Island Fm.
LaVerendrye Island Fm.
Cochrane Island Fm.
Johnston Passage Fm.
Clipper Island Fm.
South Bay Fm.
Long Island Fm.
Burnt Island Fm.
Betty Island Fm.
Drift Island Fm.
Falcon Island Syenite
East Windigo Island Fm.
0
1
kilometres

3-Map showing distribution of informal formations, Monument Bay Area.

4-Map showing locations of stained slabs of granitoids, Monument Bay Area.

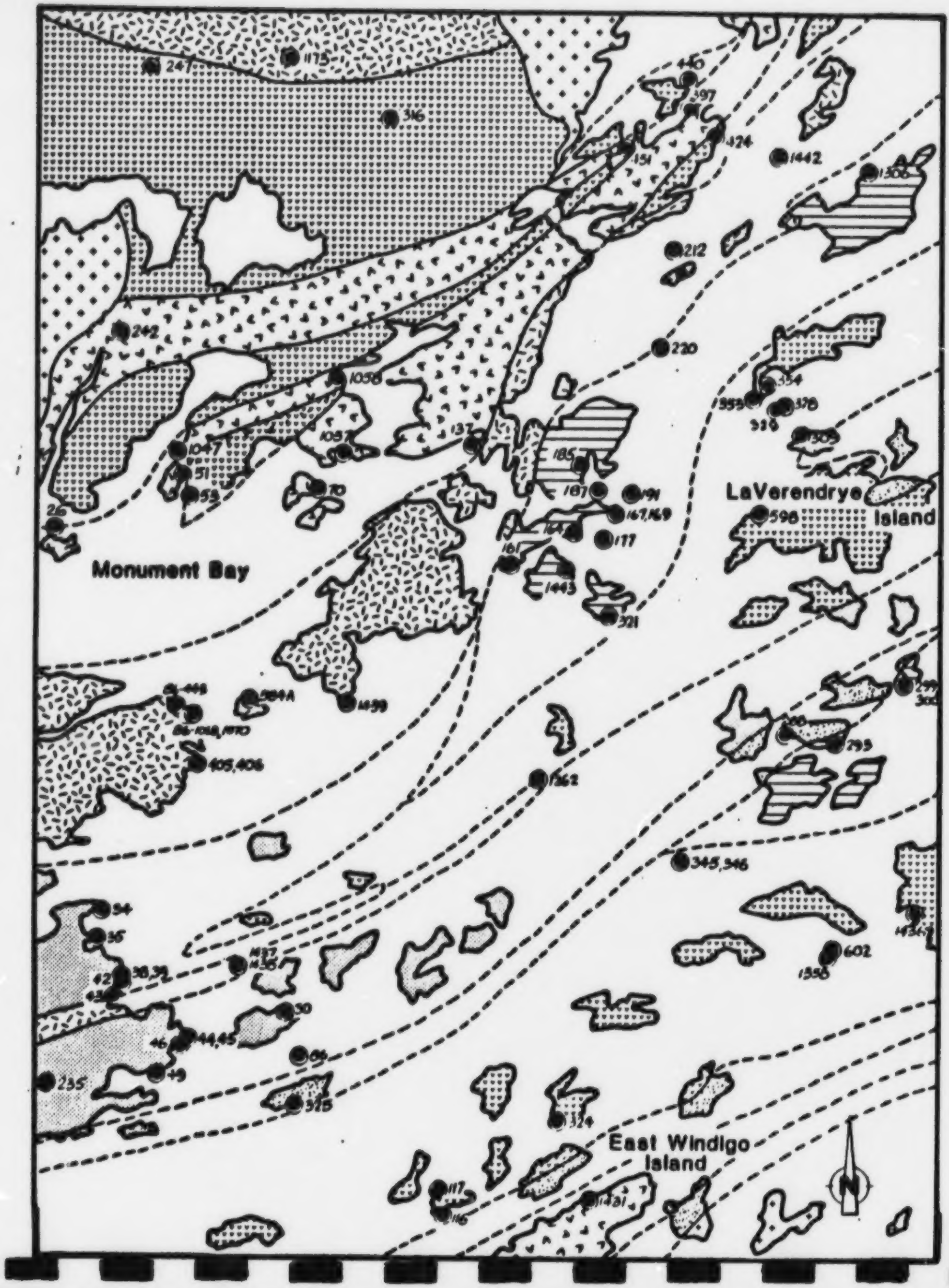

LOCATIONS OF STAINED SLABS OF GRANITOIDS, MONUMENT BAY AREA
Granitoid intrusions
Clastic metasedimentary rocks
ALKALIC VOLCANICS
Intermediate to felsic heterolithic pyroclastic rocks (plag-phyric)
Mafic, intermediate heterolithic pyroclastic rocks (cpx-phyric)
Mafic, intermediate volcanic rocks (cpx± plag-phyric)
Mafic volcanic rocks (cpx-phyric)
SUBALKALIC VOLCANICS
Mafic to ultramafic volcanic rocks
0 1 2 3 4
kilometres
N
Monument Bay
LaVerendrye Island
East Windigo Island
2104
2019
2100
1052
1012



5-Modal analyses of granitoid rocks in Quartz- Alkali Feldspar-Plagioclase triangular diagram (Streckeisen 1976), Monument Bay Area.

6. -

LOCATIONS OF WHOLE ROCK GEOCHEMISTRY SAMPLES, MONUMENT BAY AREA


Monument Bay
LaVerendrye Island
East Windigo Island
N
247
1175
316
242
1058
1047
51
53
26
1097
70
137
151
397
124
1442
1306
212
220
185
187
191
167,169
164
177
161
1443
321
1439
405,406
1362
354
378
598
293
345,346
602
1358
34
36
38,39
42
44,45
46
49
50
325
324
117
116
1431

▨ Granitoid intrusions

▨ Clastic metasedimentary rocks

ALKALIC VOLCANICS

▨ Intermediate to felsic heterolithic pyroclastic rocks (plag-phyric)

▨ Mafic, intermediate heterolithic pyroclastic rocks (cpx-phyric)

▤ Mafic, intermediate volcanic rocks (cpx ± plag-phyric)

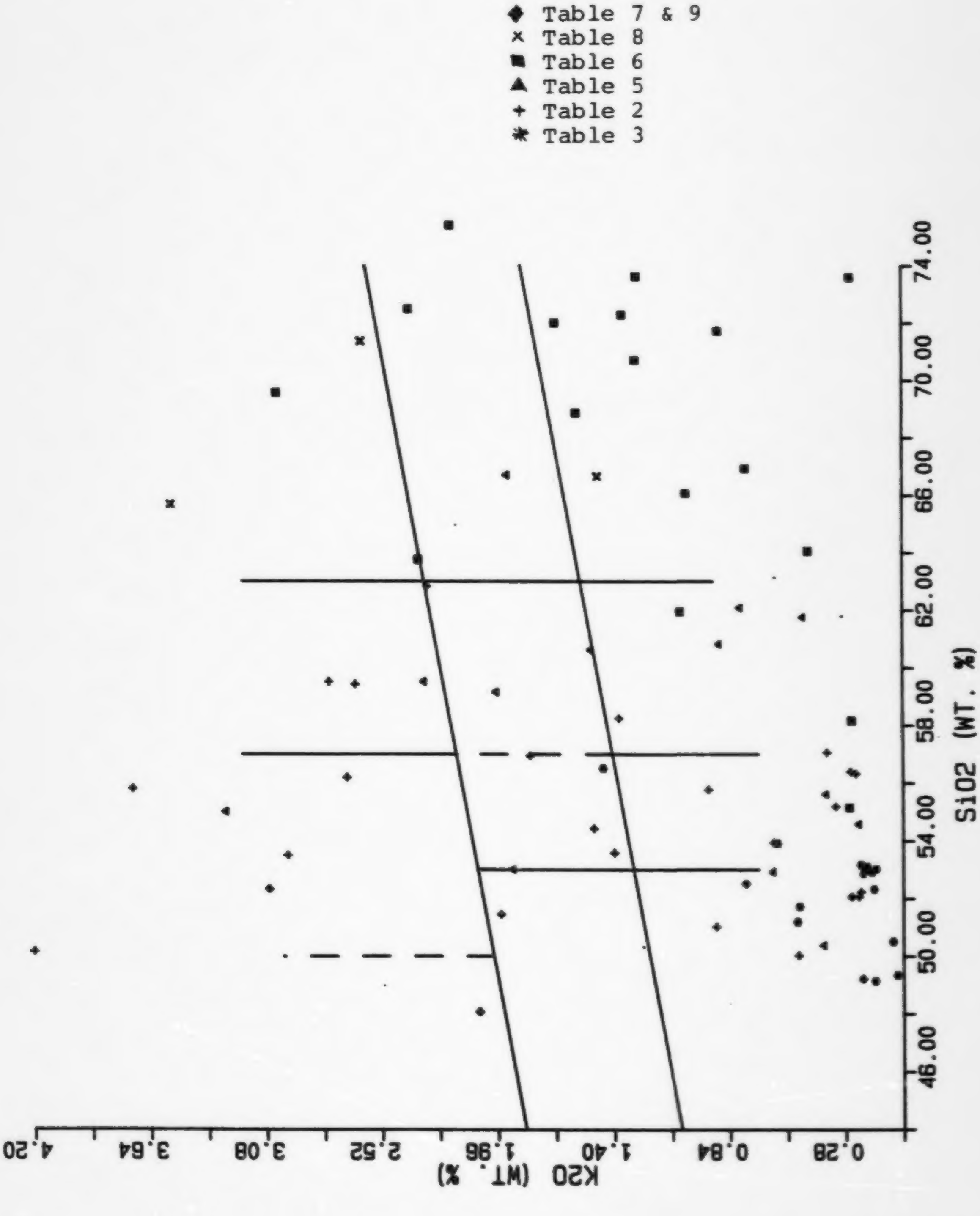
▨ Mafic volcanic rocks (cpx-phyric)

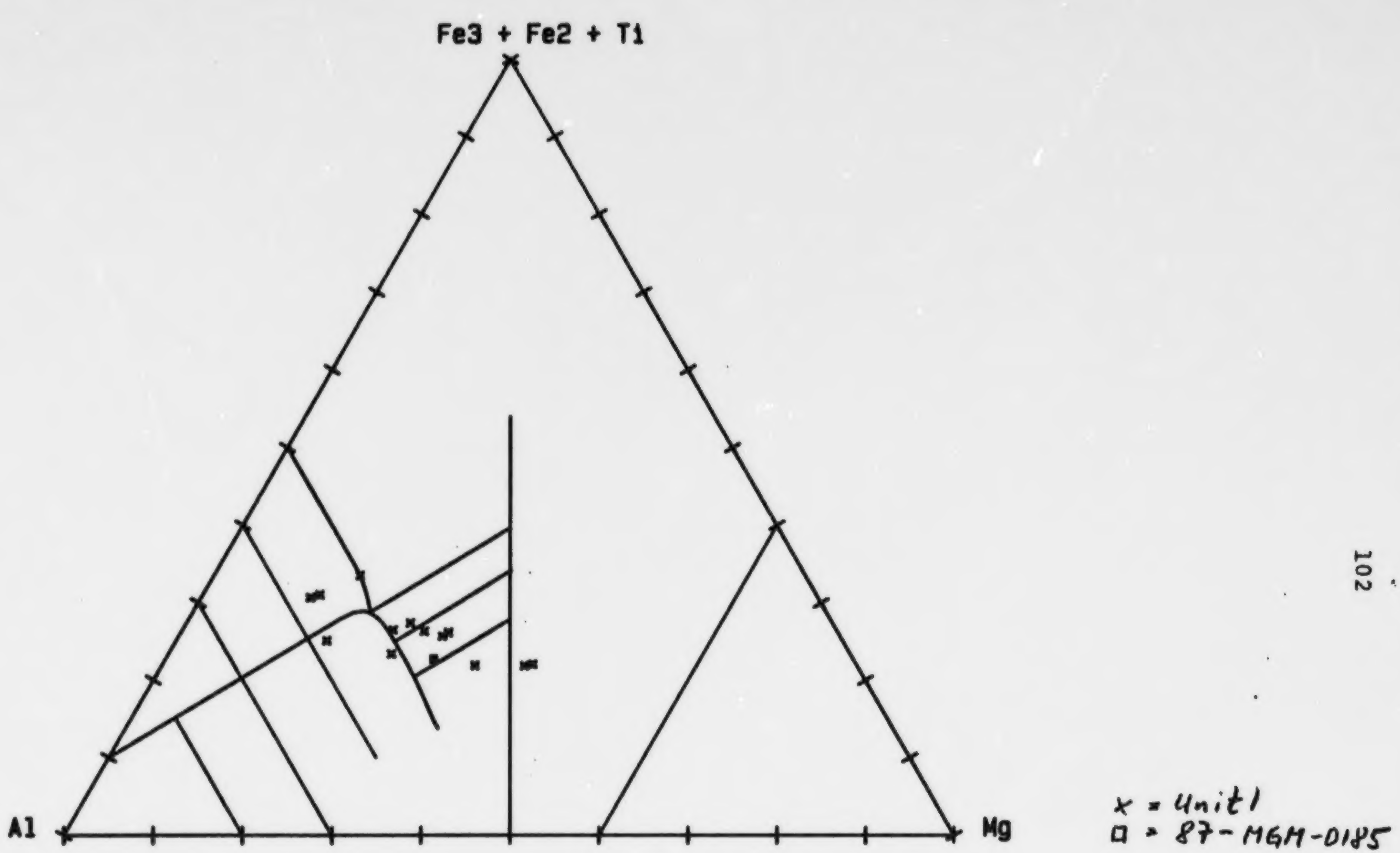
SUBALKALIC VOLCANICS

▨ Mafic to ultramafic volcanic rocks

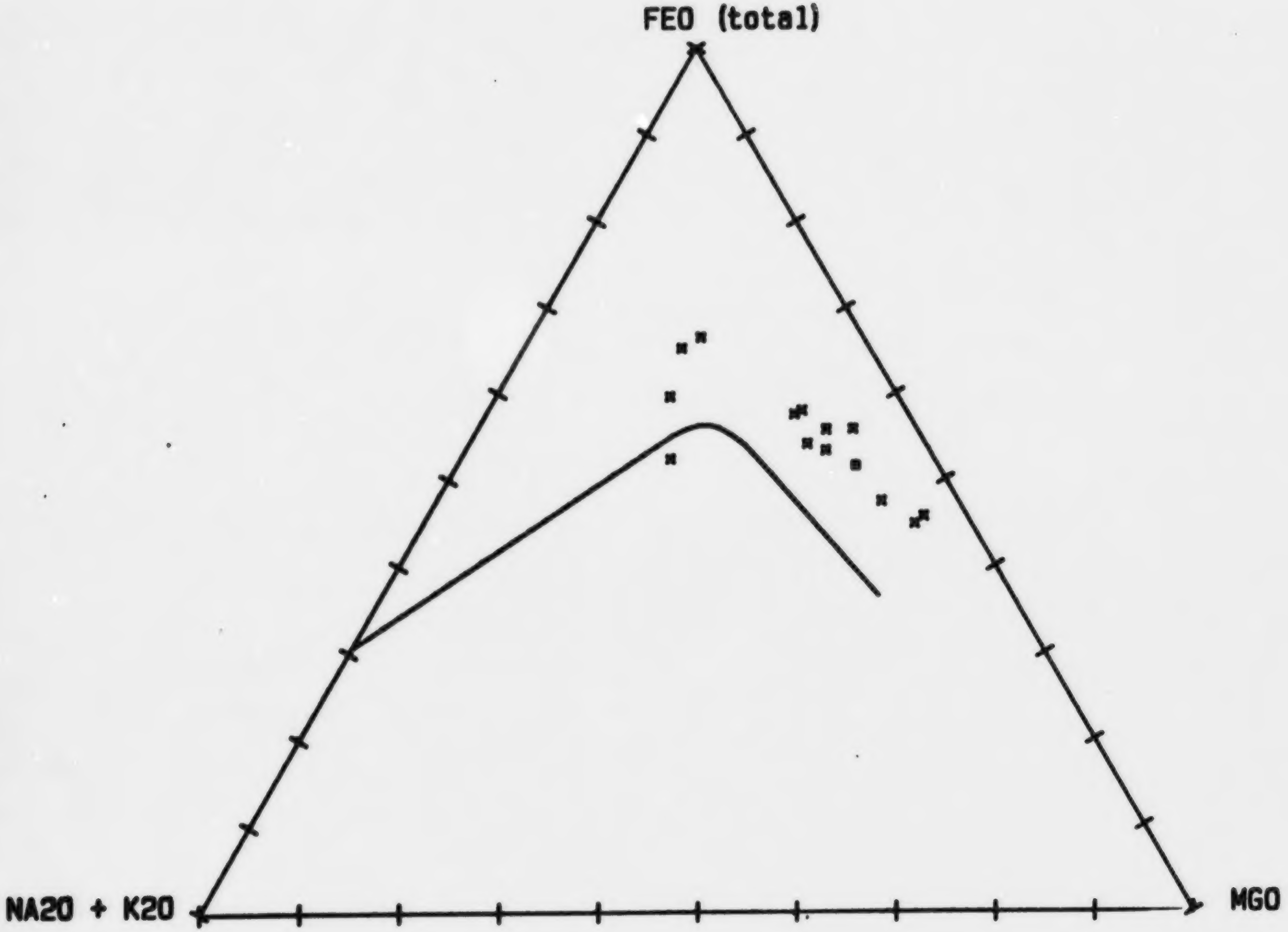
0 1 2 3 4
kilometres

7- K_2O vs SiO_2 diagram, Monument Bay Area.





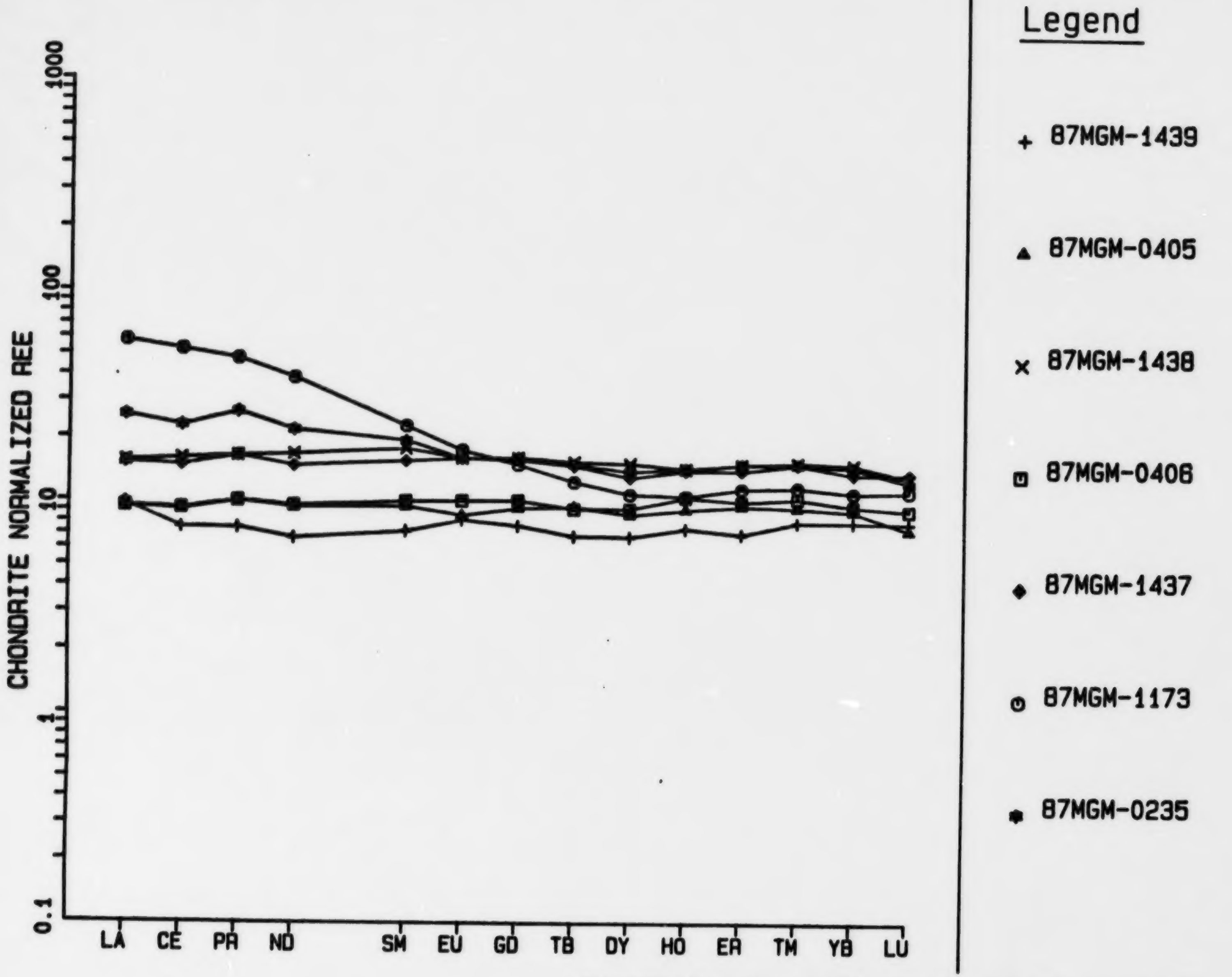
8-Jensen cation diagram, subalkalic metavolcanics, Monument Bay Area.



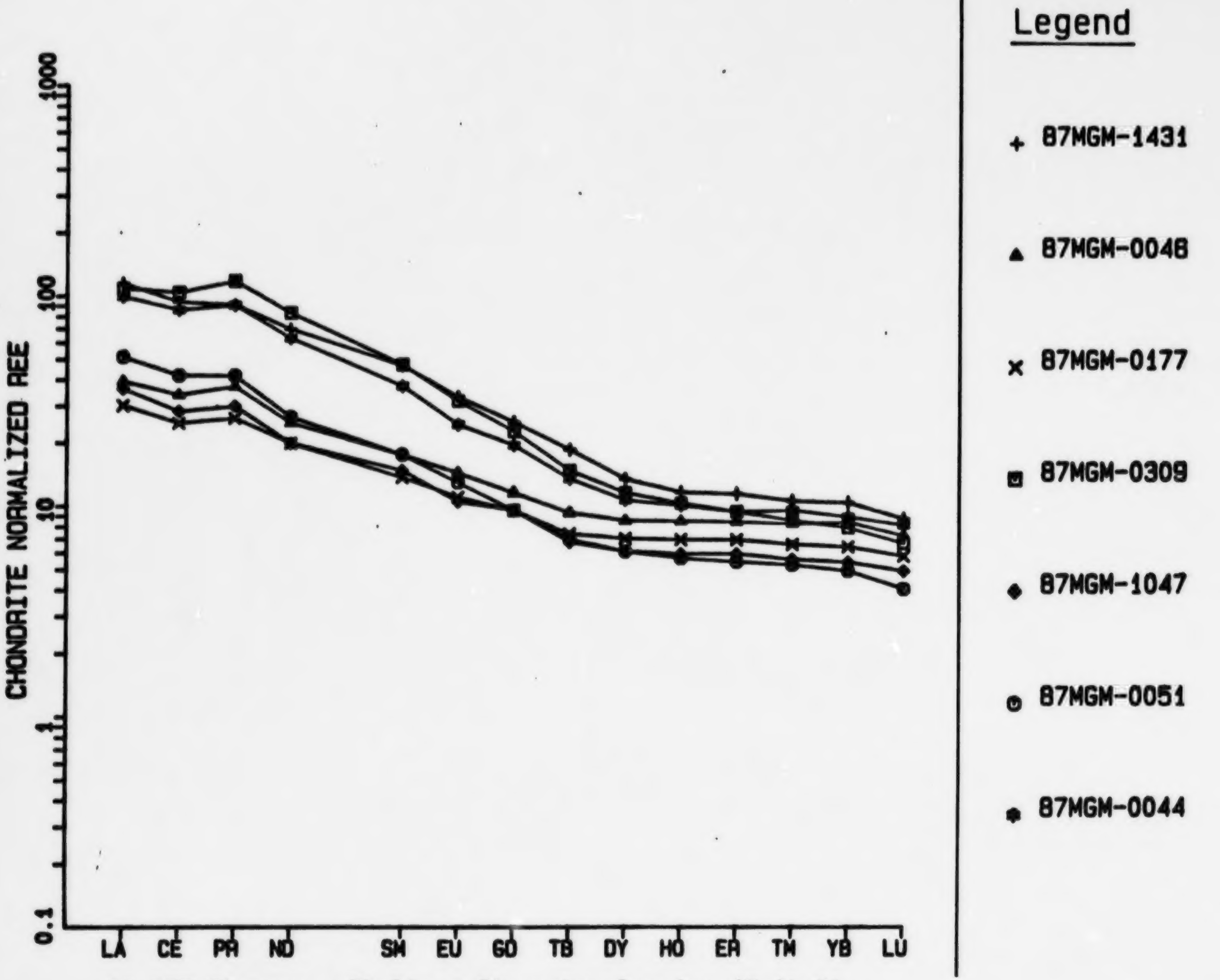
9- AFM diagram, subalkalic metavolcanics, Monument Bay Area.

Fig. 9
1987-7

x = unit 1
□ = 87 MGM 011



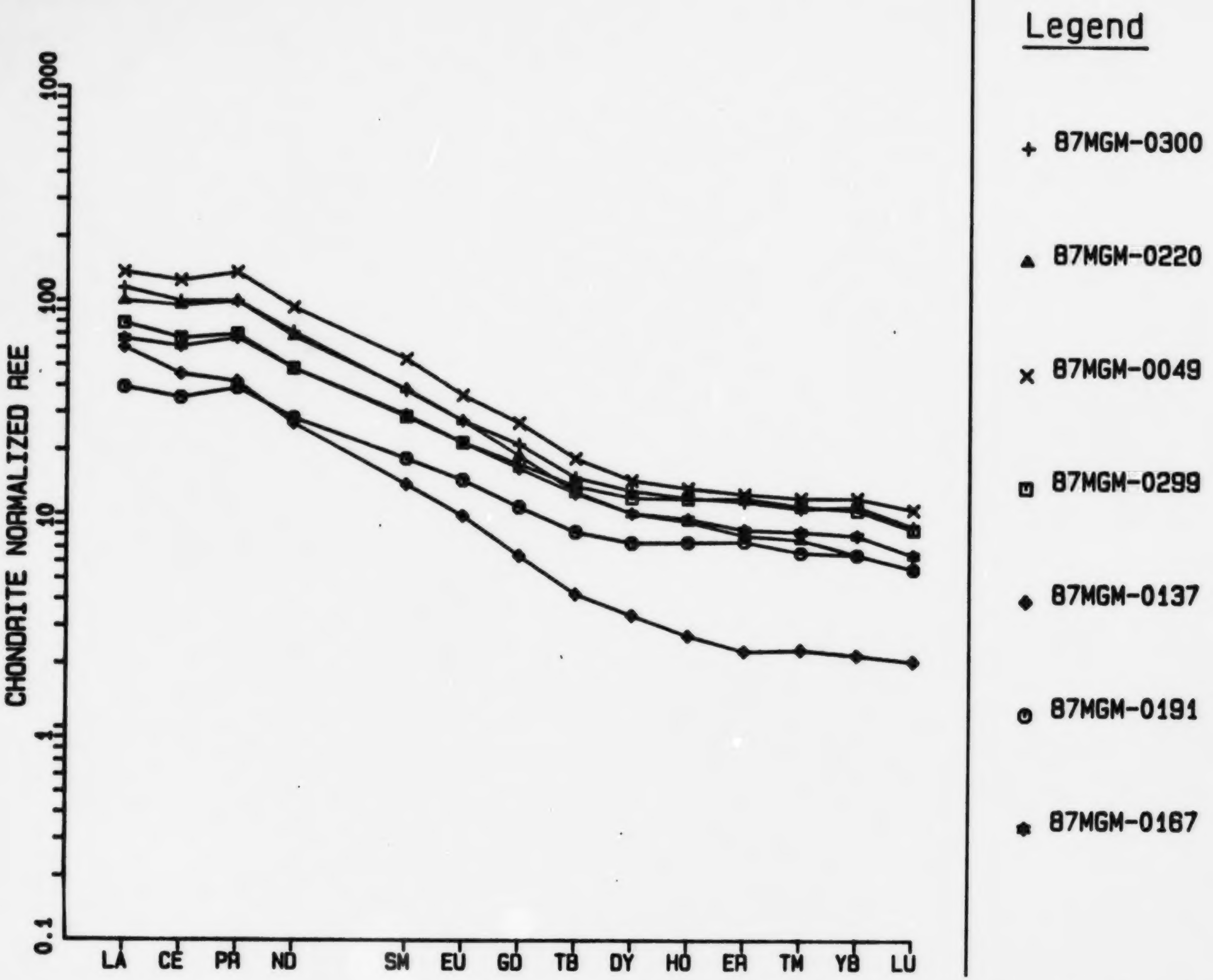
10-REE diagram, mafic to ultramafic metavolcanics (Unit 1), Monument Bay Area.



11-REE diagram, alkalic mafic metavolcanics (Unit 2), Monument Bay Area.

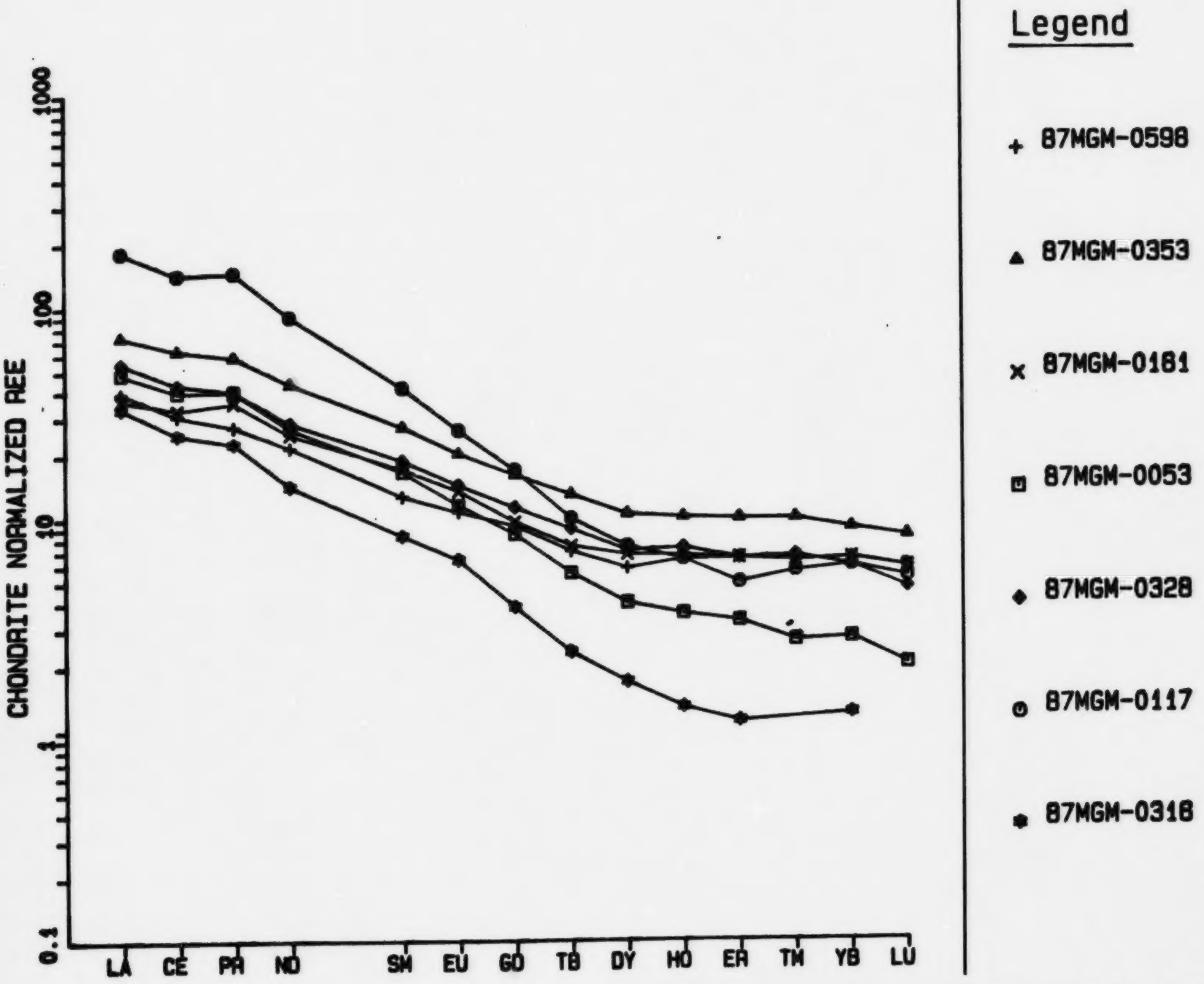
t 2

1987-

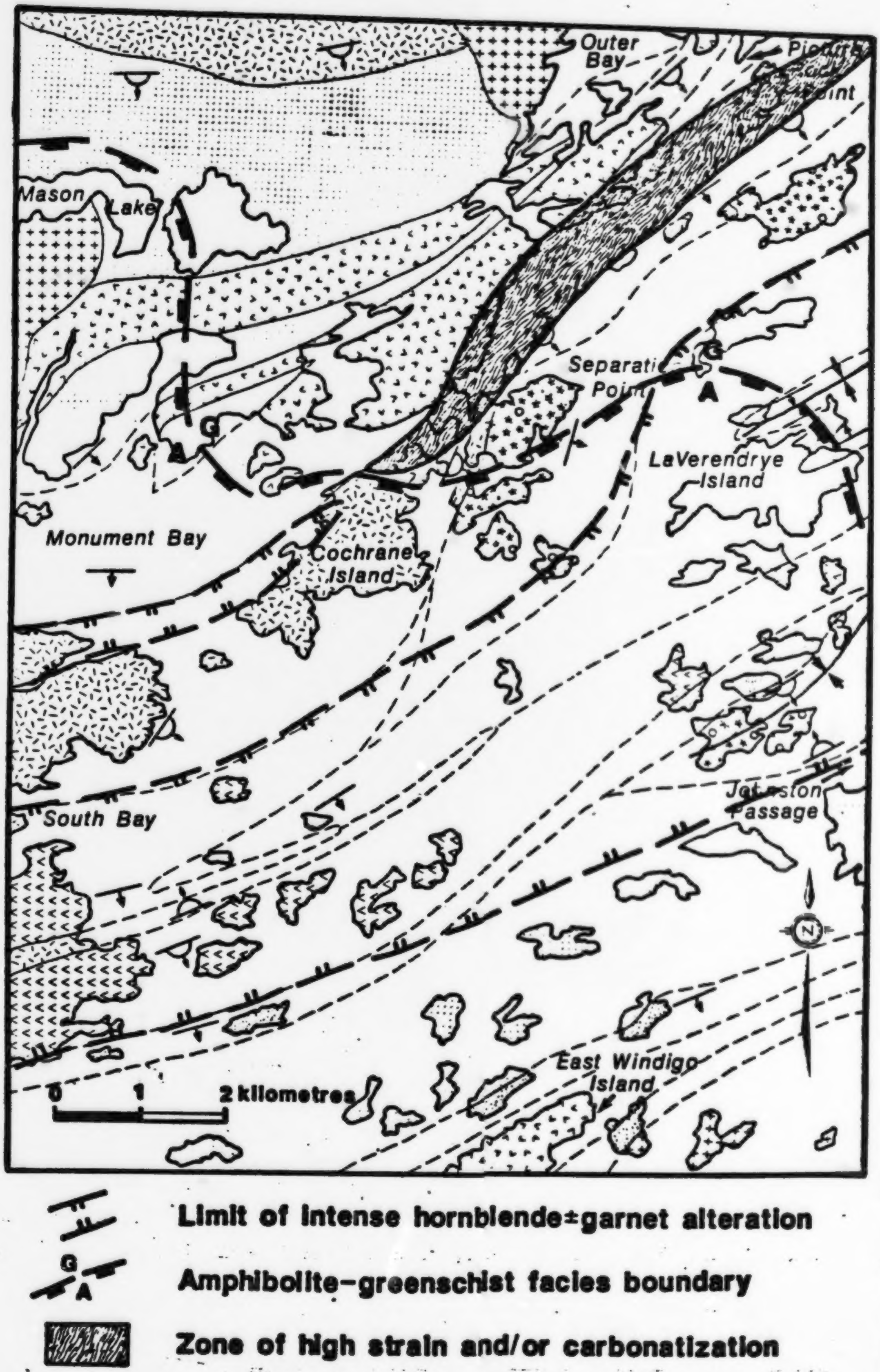


12-REE diagram, intermediate metavolcanics (Unit 3),

Monument Bay Area.



13-REE diagram, intermediate-felsic metavolcanics (Unit 4), Monument Bay Area.

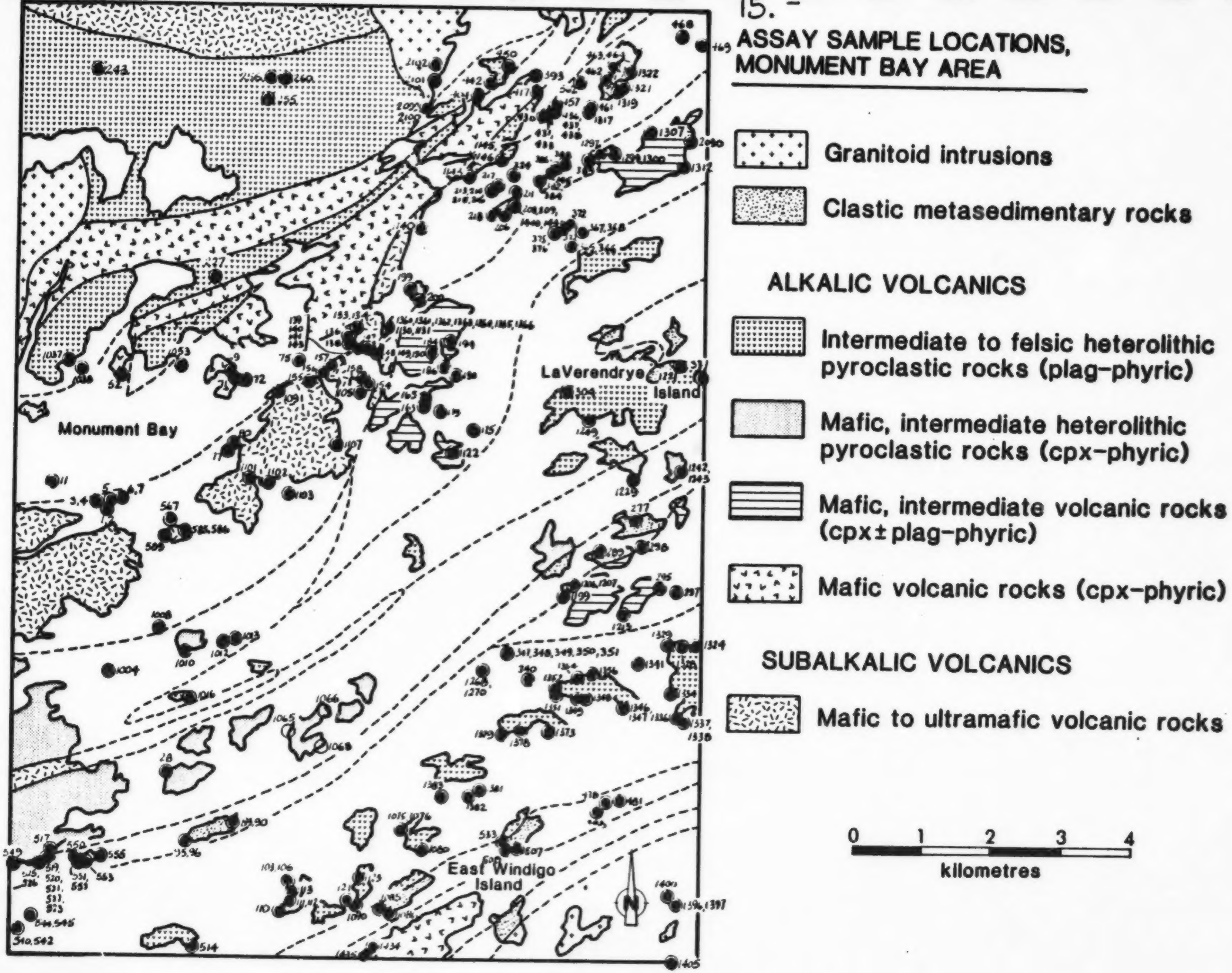

Outer Bay
Pictured Point
Mason Lake
Separation Point
G
A
LaVerendrye Island
Monument Bay
Cochrane Island
South Bay
Johnston Passage
East Windigo Island
0 1 2 kilometres
N
Limit of intense hornblende±garnet alteration
Amphibolite-greenschist facies boundary
Zone of high strain and/or carbonatization

14-Map showing distribution of amphibolite-greenschist metamorphic transition, alteration, and anomalous assay results, Monument Bay Area.

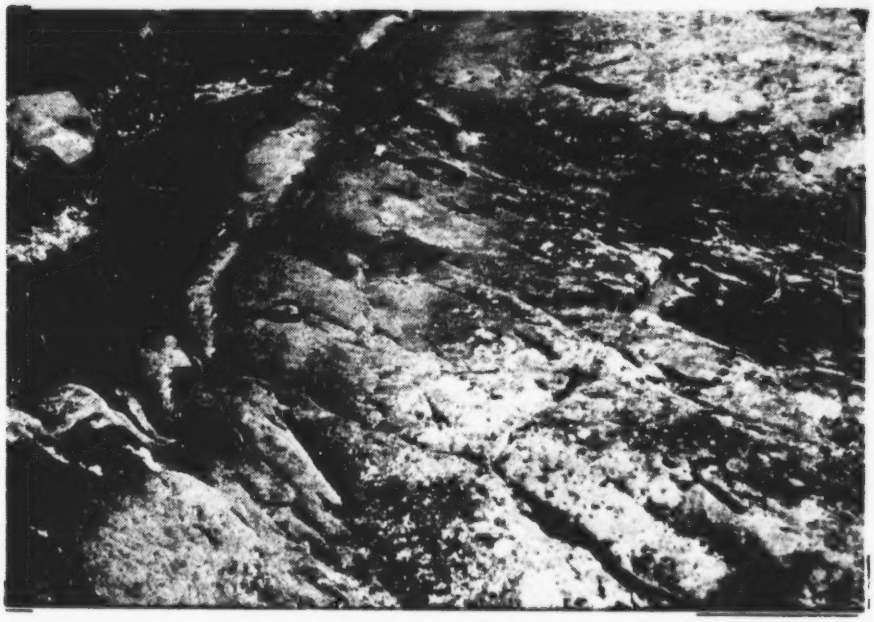
Fig ~~15~~ 14 Monument Bay A. [illegible]

15. -

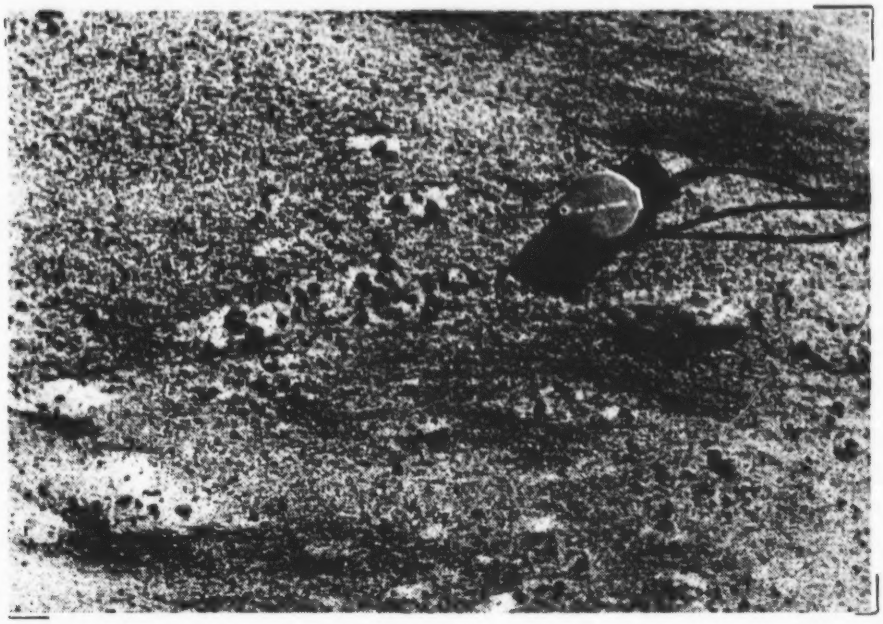
ASSAY SAMPLE LOCATIONS, MONUMENT BAY AREA


Monument Bay
LaVerendrye Island
East Windigo Island
N
Granitoid intrusions
Clastic metasedimentary rocks
ALKALIC VOLCANICS
Intermediate to felsic heterolithic pyroclastic rocks (plag-phyric)
Mafic, intermediate heterolithic pyroclastic rocks (cpx-phyric)
Mafic, intermediate volcanic rocks (cpx± plag-phyric)
Mafic volcanic rocks (cpx-phyric)
SUBALKALIC VOLCANICS
Mafic to ultramafic volcanic rocks
0
1
2
3
4
kilometres

PHOTOGRAPHS

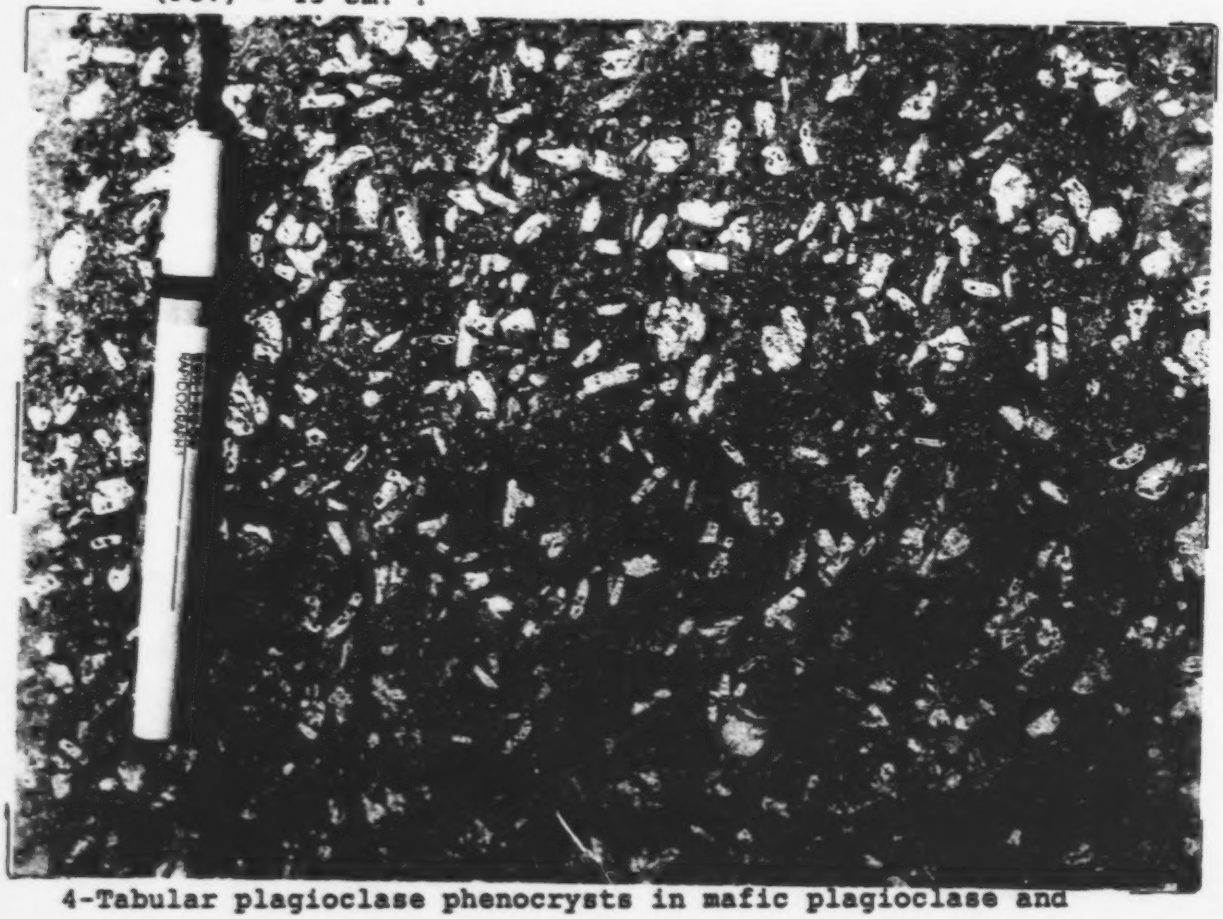


1-Pillowed and massive basaltic komatiites, South Bay formation, South Bay. Rubbly, carbonatized flow contact can be seen immediately below hammer.

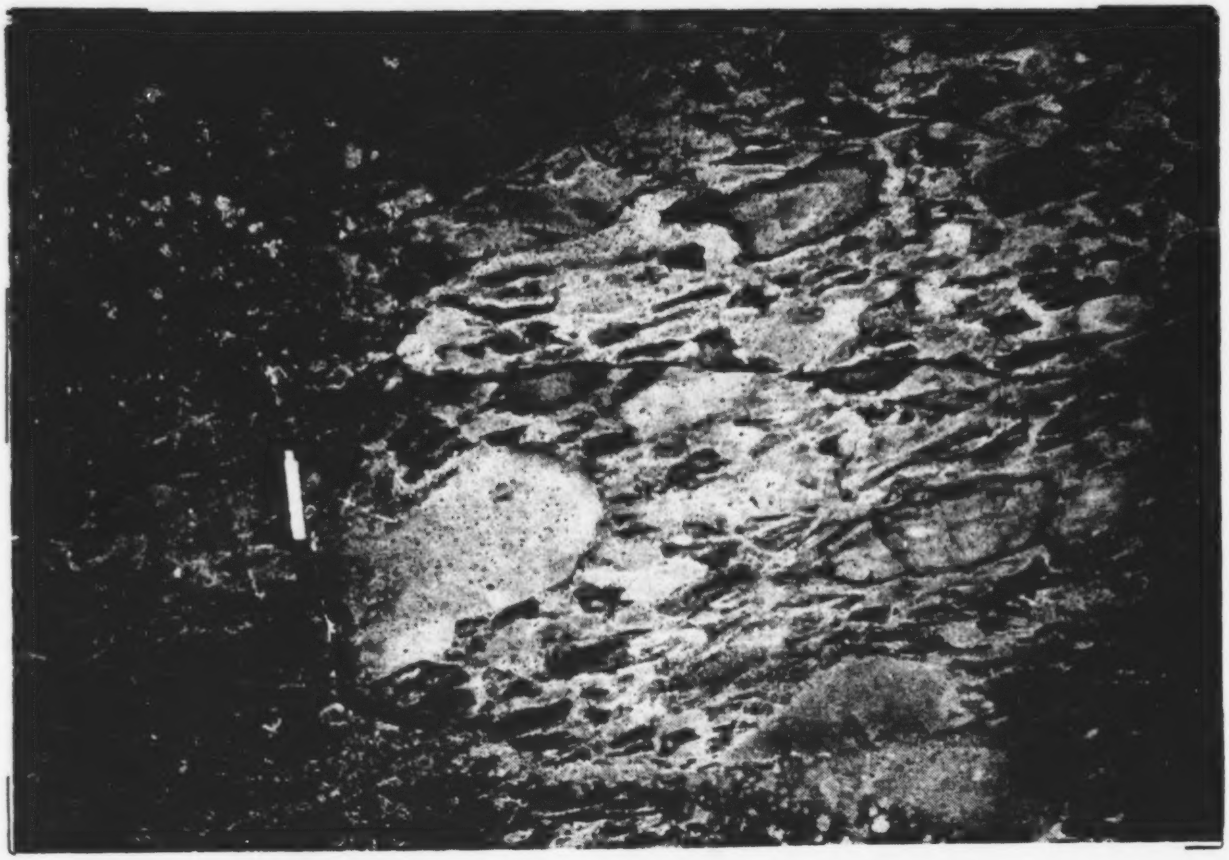


2-Clinopyroxene phenocrysts in alkalic mafic metavolcanics, Monument Bay formation, Monument Bay.

3-Flattened and "biotitized" clinopyroxene phenocrysts, Monument Bay formation, Monument Bay. Field of view (FOV) = 15 cm. .

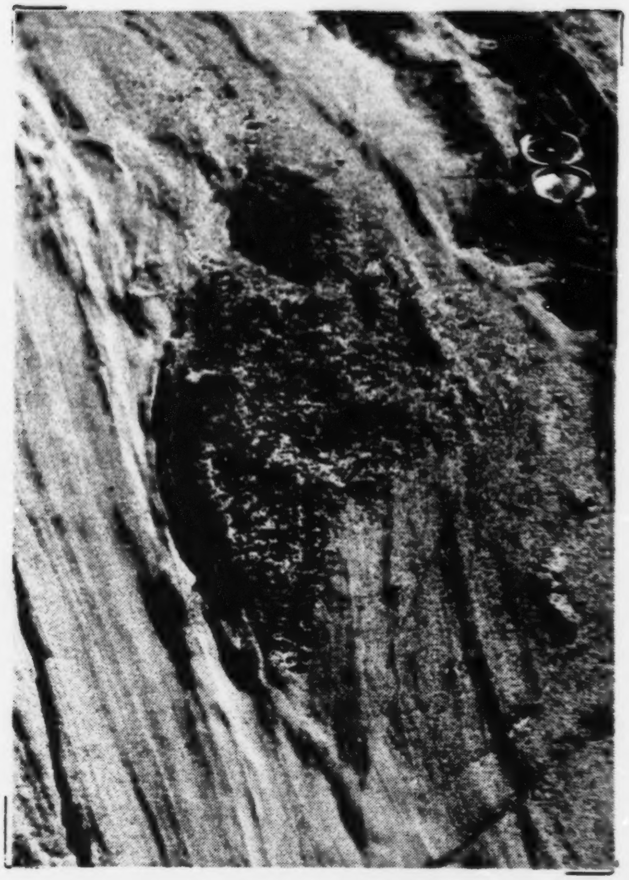


4-Tabular plagioclase phenocrysts in mafic plagioclase and clinopyroxene-phyric subvolcanic dike, Separation Point Formation, northeast of Separation Point.

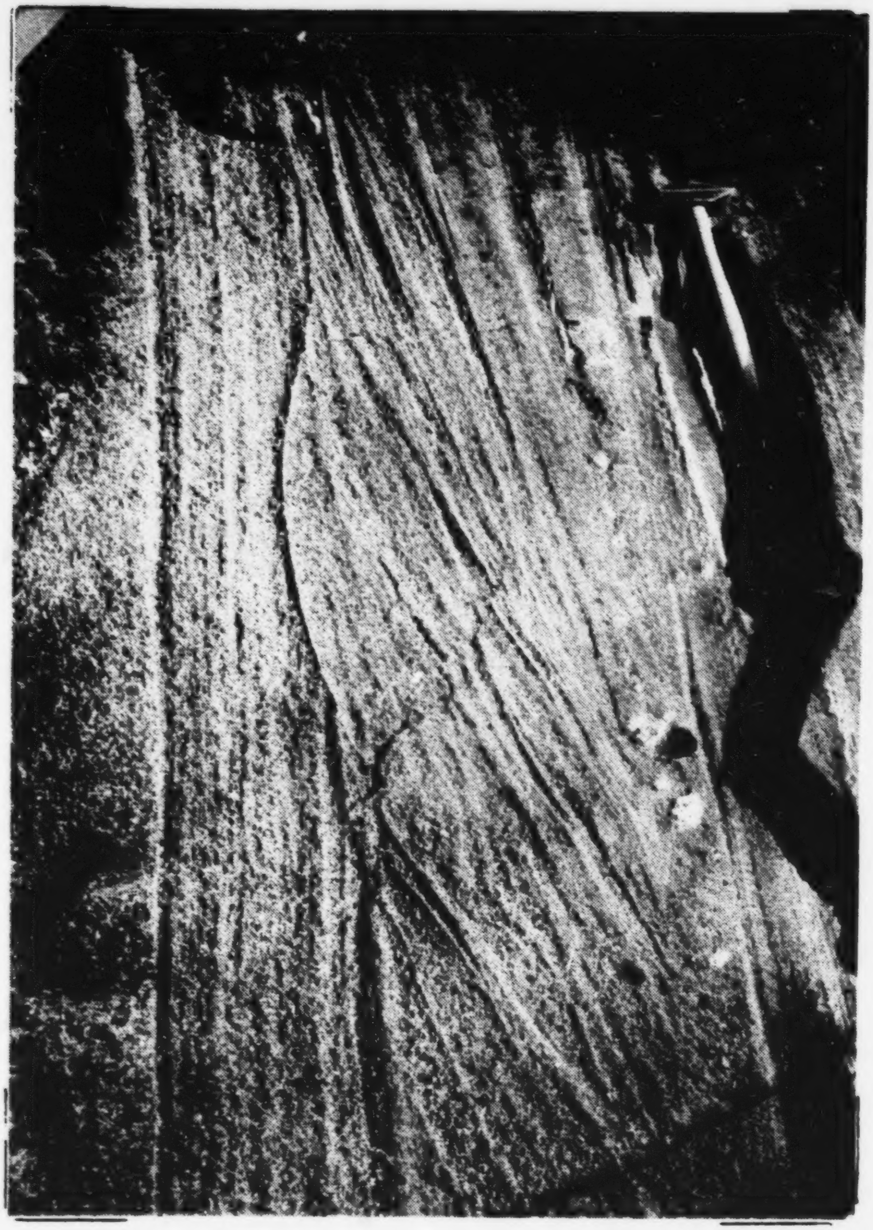


5-Autoclastic clinopyroxene-phyric flow (blocky flow),
Monument Bay formation, Monument Bay.

6-Well-bedded clinopyroxene-phyric pyroclastics, Monument Bay formation, Monument Bay.



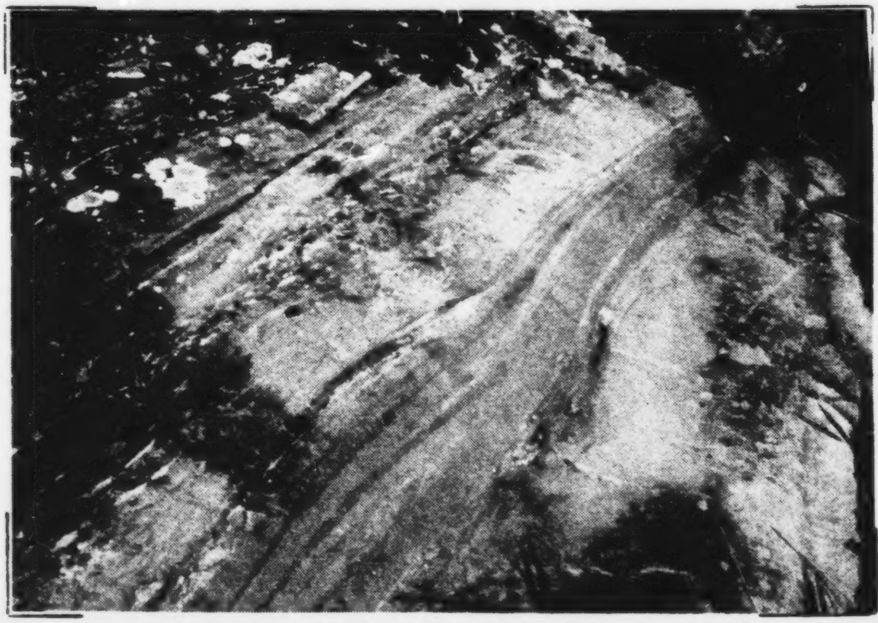
7-Bomb sag in clinopyroxene-phyric pyroclastics, Monument Bay formation, Monument Bay.

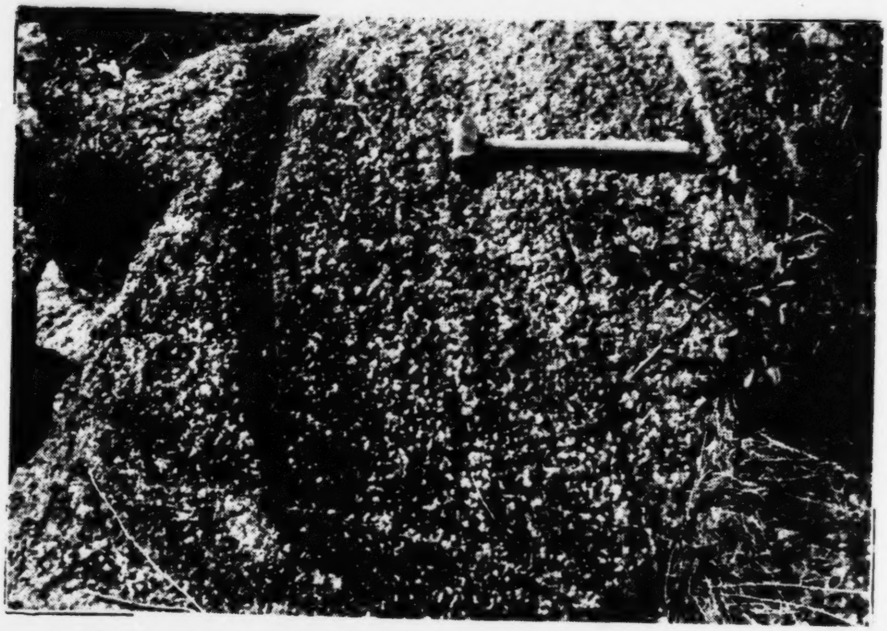


8-Scour and fill, cross bedding in clinopyroxene-phyric tuffs, Separation Point formation, Separation Point.

9-Plagioclase-phyric pillow breccia, Johnston Passage Formation, south of La Vérendrye Island.

10-Coarse bedded wackes, Royal Island Formation, north of La Vérendrye Island.



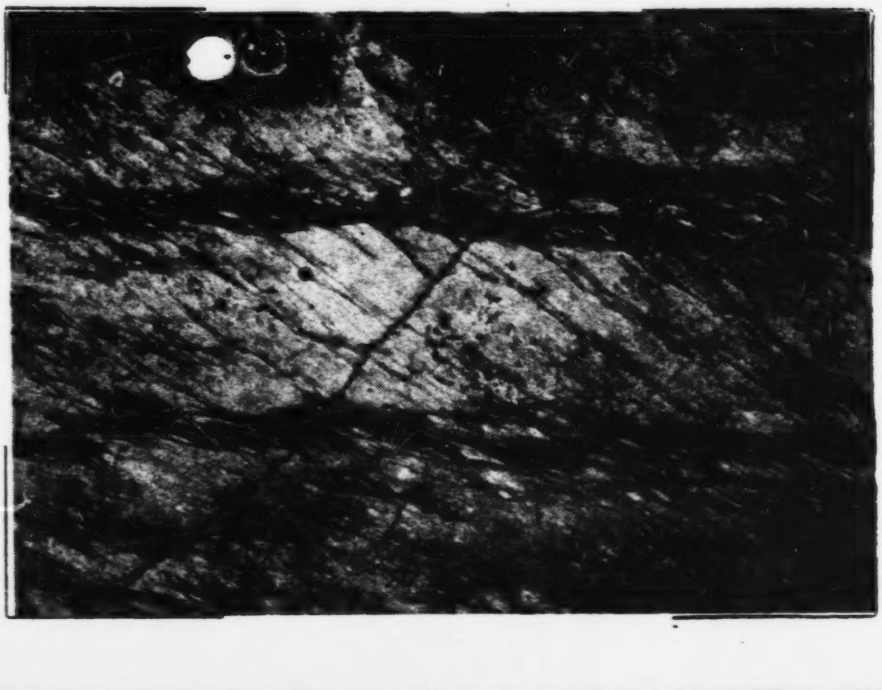


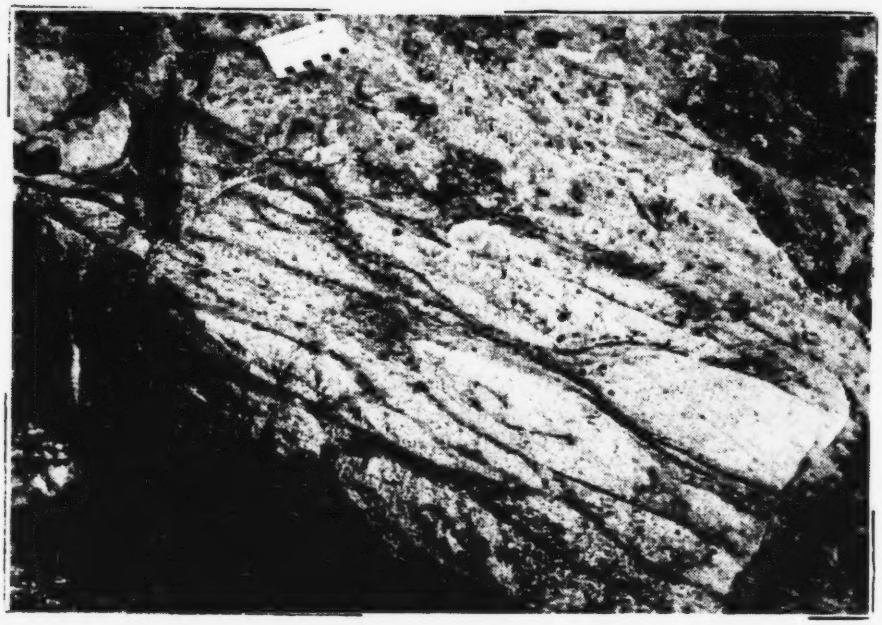
11-Microcline-megacrystic syenite, southeast part of map area.

12-Sheared and carbonatized mafic metavolcanics within the Monument Bay Deformation Zone, north of Separation Point.

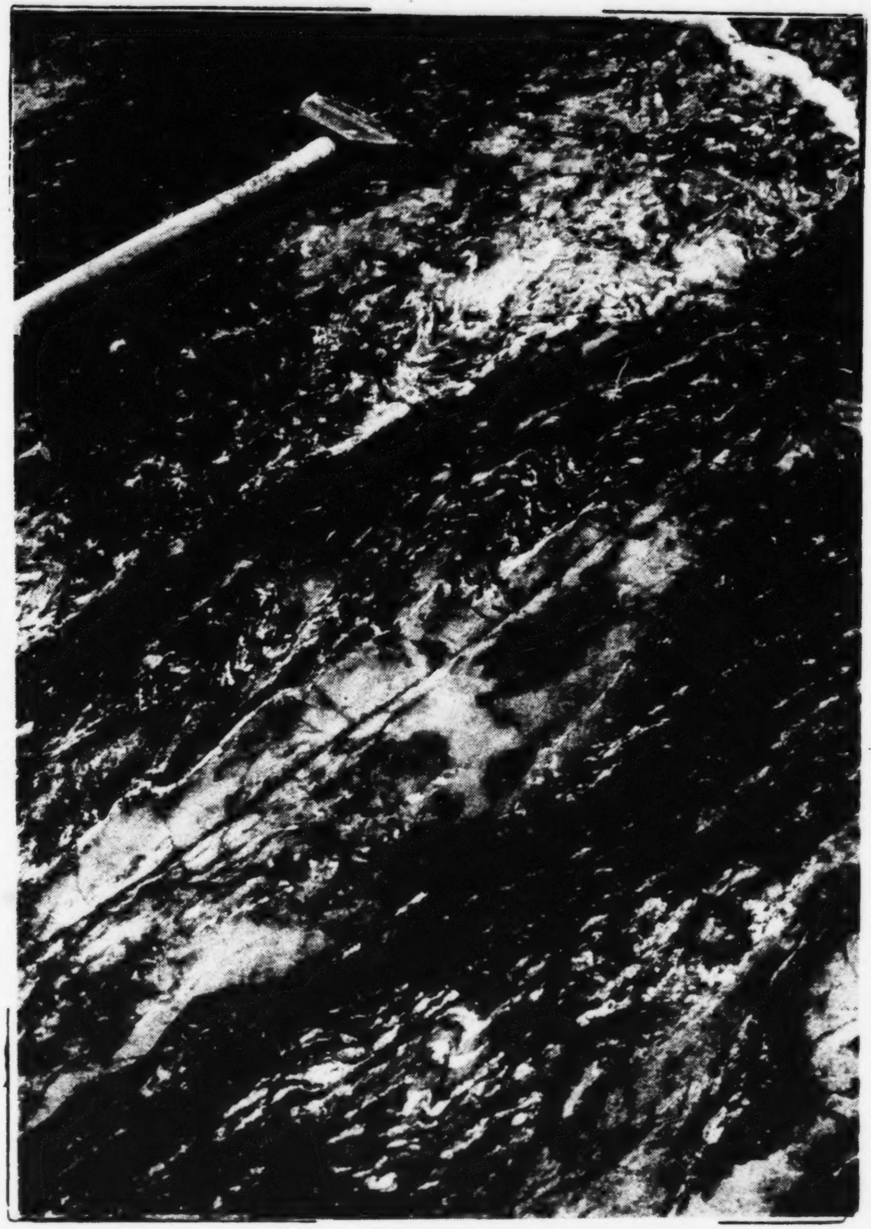
13-Quartz-carbonate-pyrite vein within shear zone in mafic metavolcanics, north of Separation Point.

14-Minor sinistral offset of F1 foliation along 070° trending shear fracture, Drift Island formation, Drift Island.

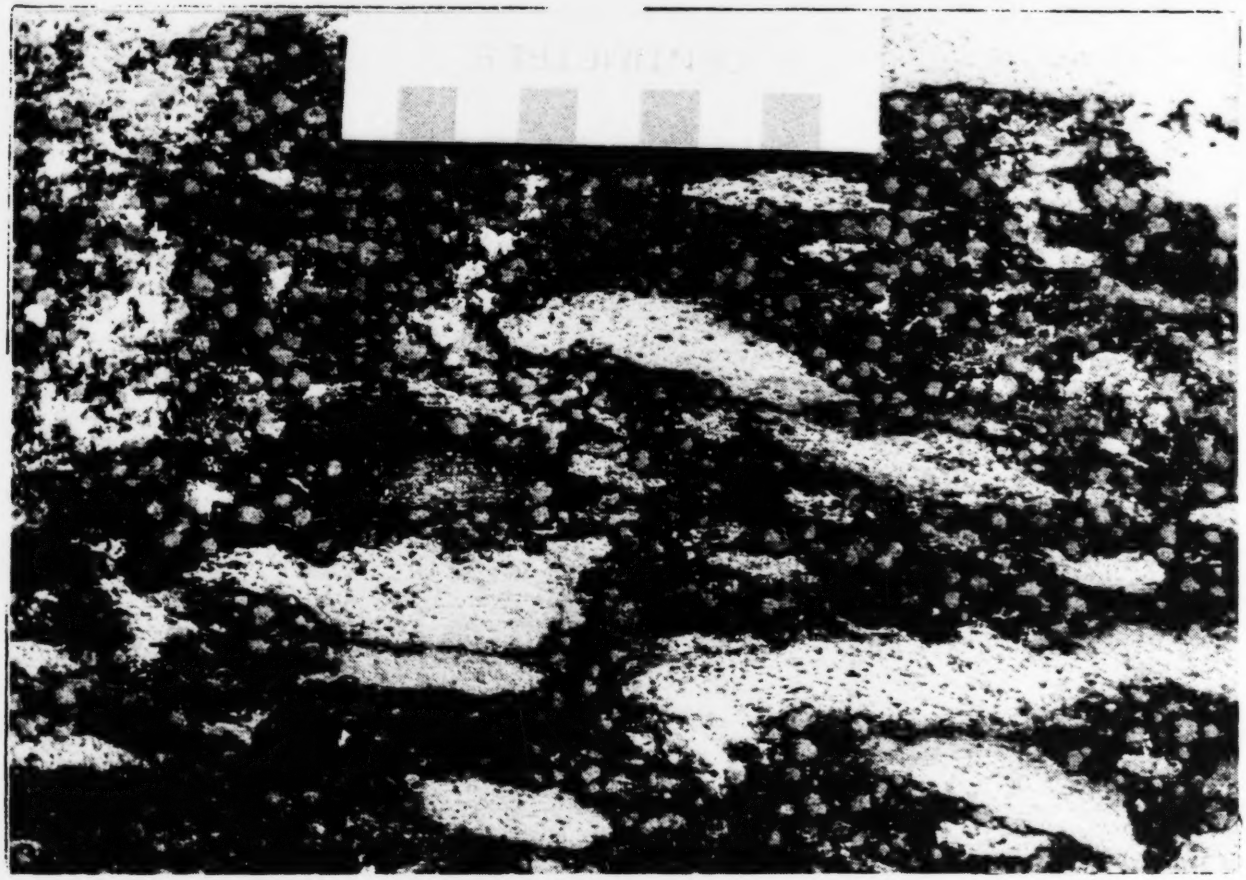




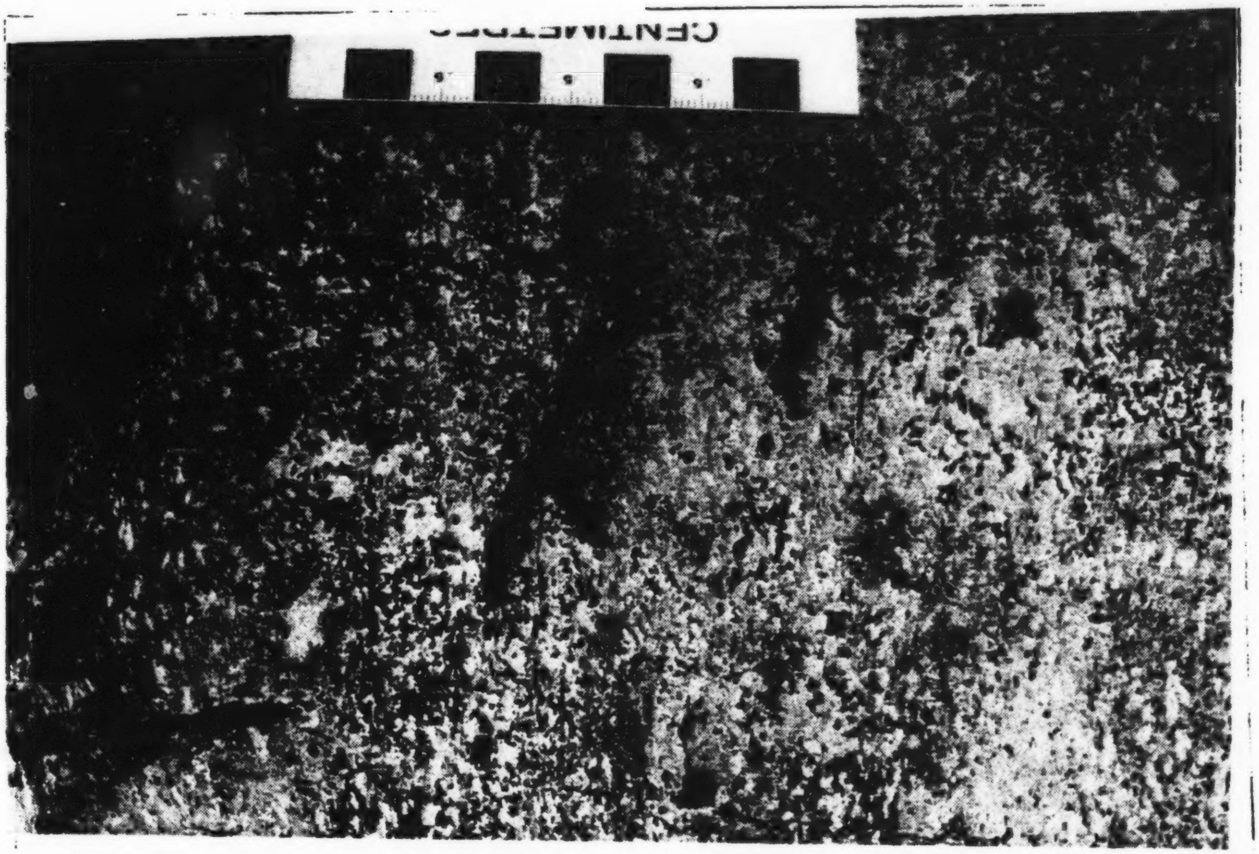
15-Anastomosing shear fractures in intermediate-felsic sill, Drift Island formation.



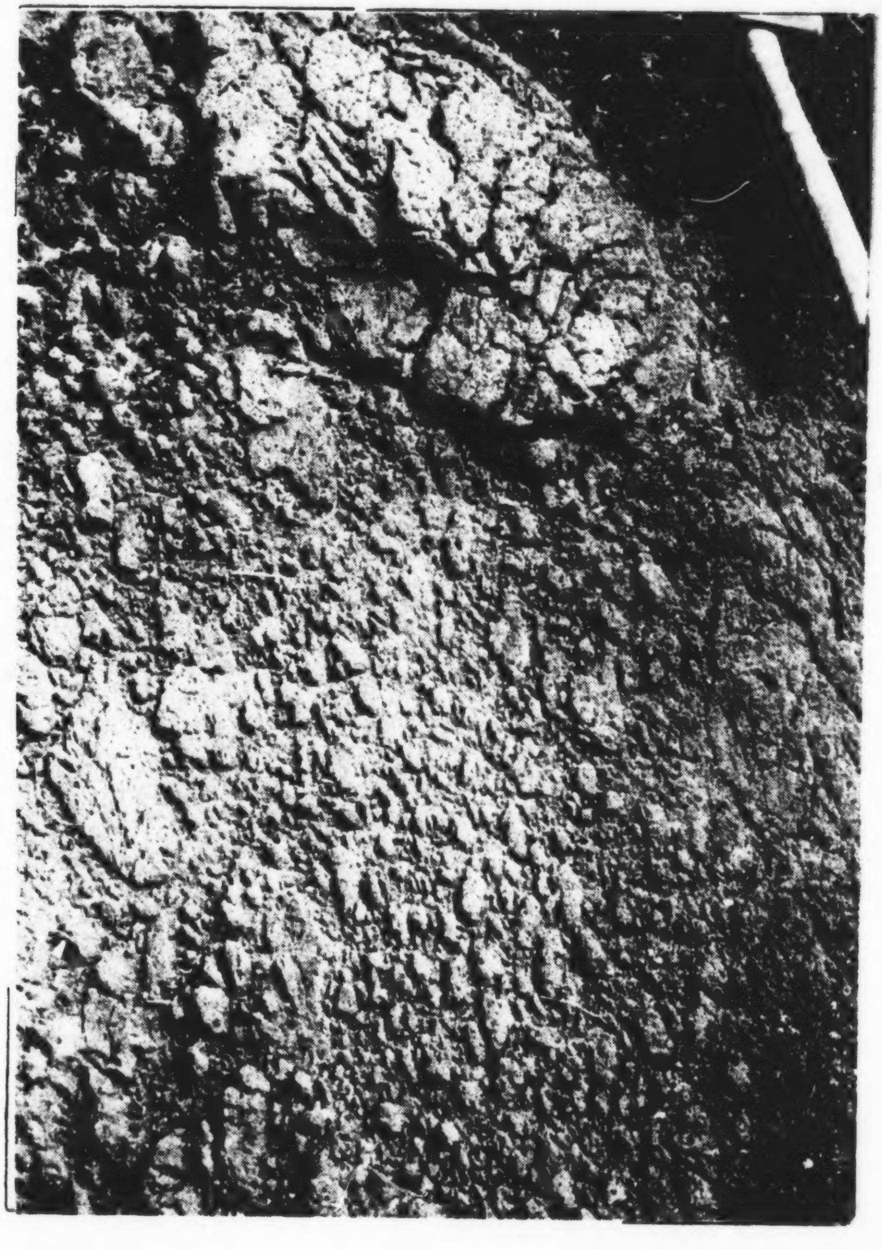
16-Folded and migmatitic metasediments, Betty Island formation, Ike Island.



17-Preferential hornblende and garnet alteration of hyaloclastic matrix of pillow breccia. Clasts are only weakly to moderately altered. Johnston Passage formation, north of Falcon Island.



18-Amphibolitized plagioclase-phyric pillowed intermediate flow, Johnston Passage formation, south of La Vérendrye Island. Note relict plagioclase phenocrysts.



19-Intensely carbonatized autoclastic clinopyroxene-phyric mafic flow, Monument Bay formation, south of Outer Bay.

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